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THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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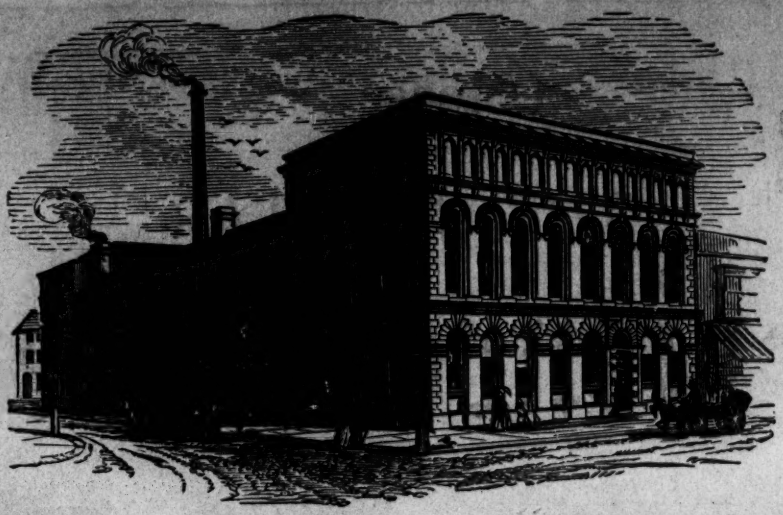

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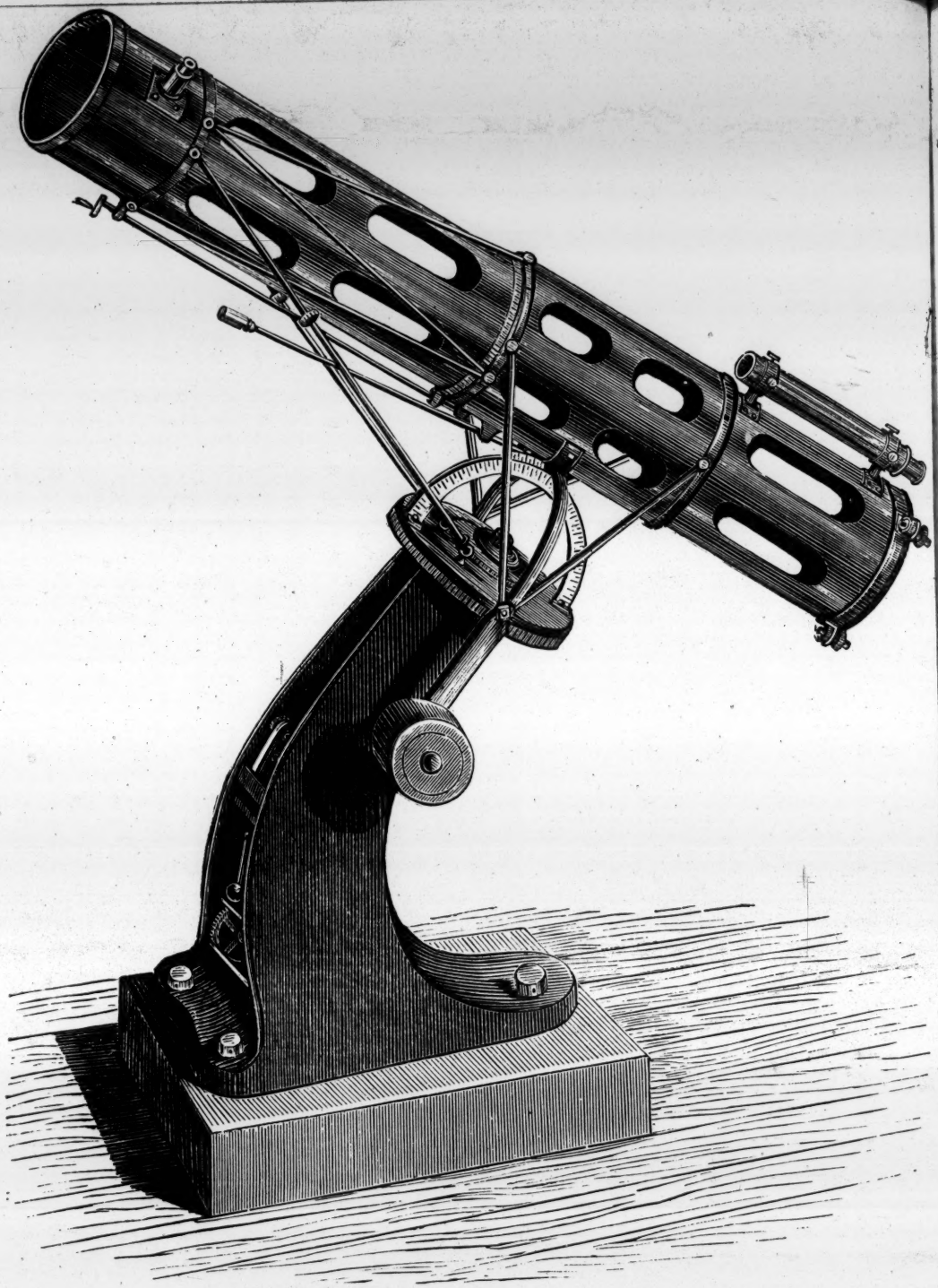

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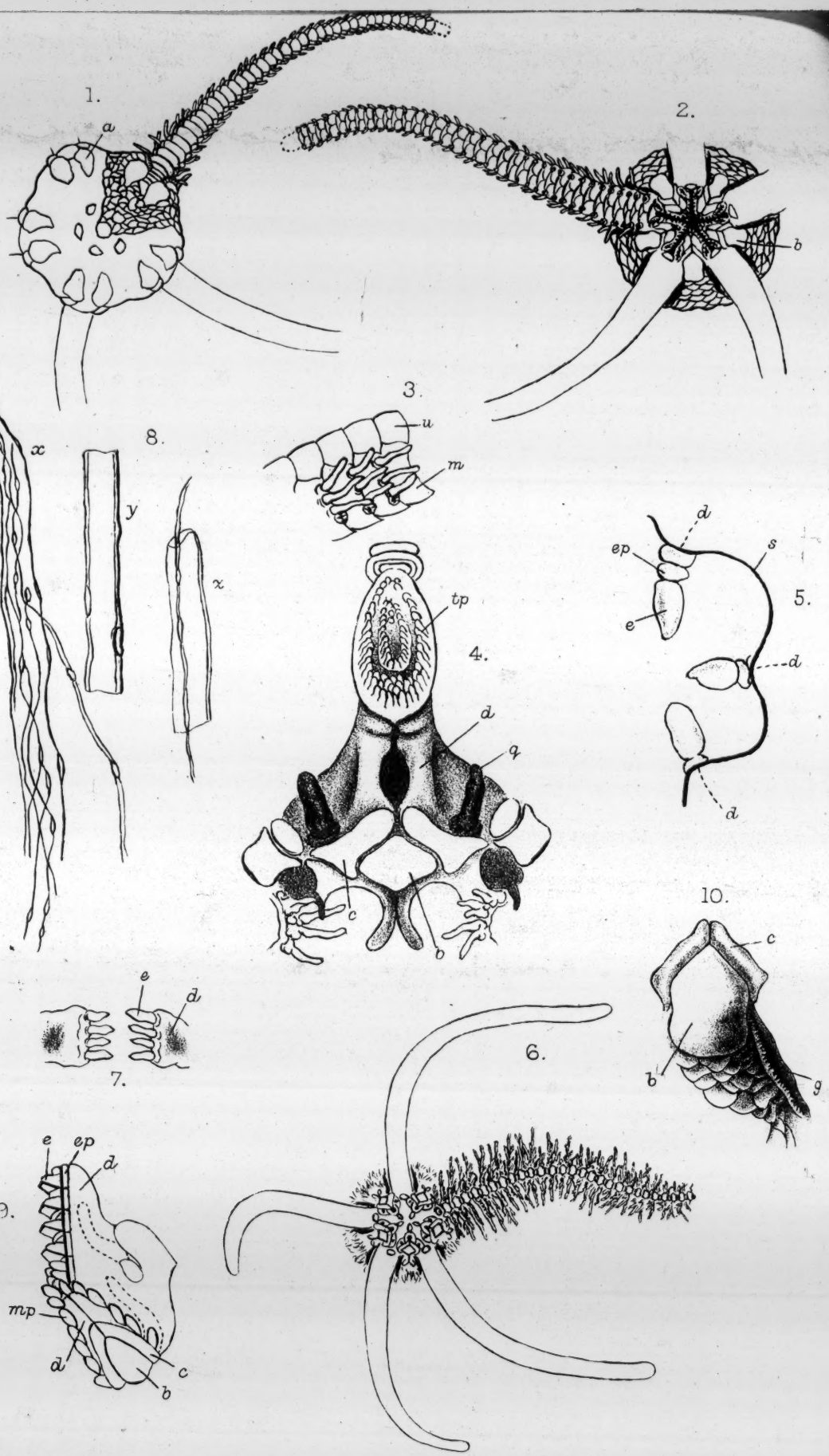

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NOTES ON THE OPHIURANS, OR THE SAND AND BRITTLE STARS.

By Professor P. MARTIN DUNCAN, M.B. (Lond.) F.R.S., &c.

PLATE VII.

THE marine invertebrata, which are called Echinodermata, on account of their possessing a more or less perfect covering of sometimes spiny, and usually geometrically shaped pieces of carbonate of lime, form a very large and natural group, which is very well defined on one and not so perfectly on the other side of the zoological scale.

Cuvier made the Echinodermata to form a class of the sub-kingdom Radiata, and Agassiz insisted on retaining this nomenclature, which is still employed by some excellent naturalists. The star-like markings and form, the arrangement of the structures in a raylike manner around the mouth, and the presumed absence of any two-sidedness, apparently so characteristic of the sea-anemones, corals, jelly-fish, and Echinoderms, rendered the Radiate sub-kingdom very readily separable from the worms on the one hand, and from the shapeless lower animals on the other. Like other abstract matters, classificatory zoology has its phases, grooves, fancies and fashions, although its solid progress depends on a correct balance of embryological and morphological learning under the influence of a method of judicious comparison.

There is no doubt that the Radiata were made to include some groups of creatures whose classificatory union was incongruous, and that those possessing a radiate form were associated with the shapeless, and this necessitated the limitation of the sub-kingdom. Then Leuckart, acting under a lively philosophical impulse, insisted, from the study of the structures of some of the most important Radiata, that they were positively not "all round creatures," but were two-sided or bilateral. The Echinodermata were shown not to be truly Radiate animals, and he made a special group of them. The Actinozoa and Hydrozoa were separated from the Echinodermata by their gastric peculiarities, and their cavity with a sole entrance—their hollow bowel—gave them the name of Cœlenterates. Broken apart, the Radiate sub-kingdom became a republic, and the group

Echinodermata began to seek outside alliances with the worms, just as the Cœlenterata are now anxious to annex the Spongida.

As long ago as the days of Edward Forbes, when the Radiate sub-kingdom was flourishing, that great naturalist paved the way to a late favourite zoological development. In treating of one of the great divisions of Echinodermata, the Sea Cucumbers, or Holothuriadæ, he introduced a group of creatures which he called Vermigrade Echinodermata, such as the shell-bearing *Sipunculus* and the Spoon Worm. He wrote, "In the animals of which we have now to treat, Radialism sets and Annulism appears. In their external appearance they are worms, for the likeness they bear to the Holothuriæ (Sea Cucumbers) depends on a correspondence with the vermiform and not the radiated character of those animals; but internally they afford evidence of belonging to the same great class. They are in fact Annelidous Radiata." This idea bore fruit, and set a fashion, and the attempts to unite the Echinoderms with the worms, gave way to attempts to make worms of the whole set. The Sipunculidæ and their allies were, however, put into the Vermes, and now rank as Gephyrea; but other discoveries led the urchins, five-fingered jacks and their fellow hard-skins within the domain of the worm for awhile.

The embryology, or rather the changes of form of the young Echinoderms, was studied by Müller. And it became evident from his admirable work, that not only was the Radiate type non-existent in the early stages, but that there was then an evident two-sided symmetry; the young stage approaching, for a time, the immature forms of some worms. The alliance of the Echinoderms with the worms was not, however, left where Forbes placed it. Naturalists insisted on the union of the two groups, and thus the hard-skins were, for a time, united to a very disjointed group, possessing all sorts of anomalies of structure on account of so many of its members being parasites. Commonplace naturalists did stare when such things as wheel animalcules and tape-worms were united; but having got used to it, they ceased very much to wonder when Huxley united these and the whole of the Echinodermata in a *primary category* of the animal kingdom under the head Annuloida. All have a water-vascular system, there is two-sided symmetry in all, and their ciliated larvæ are not without resemblances. Macalister, of Dublin, however, says, "the Annuloid arrangement is a convenient though unnatural grouping, as the Echinoderms are Deuterostomes, whilst most of the worms (Scolecids) included in Annuloida are Archæostomatous." The meaning of this appears to be, that in these worms the original embryonic mouth remains during life, but that in the Echinoderms, this original opening having served its purpose, does not

remain, and another is formed during the metamorphosis—a statement open to very considerable question. Years rolled on, and nerves, which once gave the clue to classification, became of as little importance as water systems, and stomachs reigned supreme as zoological guides. And Hæckel, faithful to his stomach as a zoological loadstone, noticing that in Star-fish the viscus is carried into each ray, infers that the animal is a colony of worms, united by a common head. Leaving this stroke of genius for what it is worth, it is simply necessary to remark that the last and the most remarkable phase of thought, separates the Echinodermata from the worms and Cœlenterates, and establishes them as a sub-kingdom divided into classes and orders. The classes are the Crinoidea, the Asteroidea, the Echinoidea, and the Holothurida; and the orders of the Asteroidea are the Asterida or Star-fish, and the Ophiurida, these last being divided into the sub-orders Ophiuræ and Euryaleæ.

The great fault of this classification is, the too close union of the Star-fish and Ophiurans, for these last differ very considerably from the others in their embryology, and require a class of their own.

Everybody who has visited the seaside, has seen a Star-fish and a Sea Urchin; Sea Cucumbers are common in every aquarium of importance; and what are scientifically called Ophiurans, and popularly Brittle Stars and Sand Stars are to be seen dried, or in bottles, in every museum. Sometimes these last are seen as waifs and strays on the shore, and perchance on cleaning a cod's stomach they may be turned out by the score. The most unobservant know all these things at a glance. They have something very decidedly in common, except the Sea Cucumbers, which links them together, such as the hard and somewhat spiny shell, the feelers by which they move, and the rayed appearance, and the youngest zoologist would classify them together. There is another group of these hard-skins, beautiful in shape, elegant in movement, and often dwellers on the floor of the deepest seas; but these, the Feather Stars or Sea Lilies, are not so well known except to naturalists by education.

It is interesting and also somewhat important, in examining into the life history of these groups to know that they are all very old dwellers in the seas. Very early in the world's history there were Feather Stars (*Crinoids*), Star-fish (*Asteriadœ*), and Sand Stars (*Ophiurans*); the Urchins (*Echini*) came a little later, but still in the palæozoic ages, and there are relics of the Sea Cucumber series in the Carboniferous rocks. No very great amount of structural change has occurred, as a whole, in the group since palæozoic times, and the types were thus distinct ages ago—that is to say, in Silurian times the Star-fish and

Ophiurans were in existence, and attention is directed to this fact, as it is with the class of Ophiurans that this communication deals.

There is no mistaking an Ophiuran, for its round flat body and its five slender plain or spiny arms, the whole as a rule being scaly and of many colours, distinguish it from all other things. They are of very different sizes when full grown; in some the body is an inch and a half across, and in others not more than a few lines. In most, the contour of the body is circular and flat, but in some it is pentangular, and it may be tumid or even constricted between the arms. These last vary, wonderfully, in their size, shape, construction and ornamentation, and in some instances the number five, so peculiarly characteristic of the Echinodermal structures, is departed from, and six arms exist. Moreover, it is by no means certain that some kinds have not different numbers of arms, at different periods of their lives. The top and sides of the body, are either covered with a skin, or else with geometrical plates or scales united at their sides or overlapping; they are often more or less covered with granules, little spinules, and even with groups of spines. Black, red, yellow, green, white, brown, and grey, either pure or in all sorts of tints, are common colours in the skin and spinules, and the plates are splashed with the same colours. The colour may be universal or in parts, especially in rings on the arms, and in some instances the reptile-like look of the body and arms is maintained by a square brown or white pattern greatly resembling that seen on many Ophidia. The plates are often arranged in beautiful patterns, a rosette being central with radii of plates in the space between where the arms fit in to the upper part of the body in a sort of notch. And as the plates vary in size as well as being in squares, hexagons, pentagons, and rectangles, every opportunity is given to Dame Nature's love of organic æsthetics. Close to where the arms come in, on the top, there is usually, but not invariably, a notch for them, and between it and the centre are certain plates which are constant, but are sometimes hidden, being covered with skin. Two of them are found on either side of the track of the arms, and not far from the margin or edge of the body above. They are called Radial shields, (fig. 1, *a*) and as one is on either side of the arm they are in pairs, there being five pairs in all, and six when there are six arms. On either side of the arm notch, or even nearer the centre of the upper surface, these ten plates give a character to the animal, when they are well developed.

The sides of the body are between the arms, and are usually scaled or plated, being spinulate or not. In some they are naked, that is to say, covered with skin which has little carbonate of lime in it in the form of scales or plates. When the animal is placed

on its back the under part of the body presents itself, and its middle is very pretty-looking, and very geometrical, from the quintuple repetition of regularly-shaped plates converging to the central mouth. Between the elements of this quinary arrangement are the lower parts of the arms, which come well within the body like so many radii, and reach to the slits which surround the mouth. Each arm in its radial course confines a portion of the body between it and its neighbour, and the space is limited, without by the edge of the body (the margin), and within by some plates which point to the mouth. This space is an interbrachial space, and on it, close to the arms, are slits or linear openings, one on either side usually, but in some kinds two. These lead upwards, in the proper position of the animal, into cavities—the generatives. Sometimes the interbrachial spaces are naked, but in most genera, they are covered with a less regular and smaller plating or scaling or spinuling than the upper part of the body. At the inner angle of each interbrachial space is a plate, one of which is sometimes porous, called the mouth shield (Figs. 2, 4, and 10 *b*). Within it, that is to say, nearer the centre, or, as the term is, "orally," are two smaller plates (Figs. 4, 9, 10 *c*) called side-mouth shields, and orally or internally to them is a more or less triangular mass, fringed at the free sides and tip, (Figs. 4, 9 *d*) with a few or many papillæ. Careful examination will show that the triangular surface is divided by a line running nearly from the apex to the base, and really there are two triangles side by side. These are the under surfaces of the jaws, and at their apex the innermost papilla is upon a small plate, the under part of which is seen from below, and it is called the jaw plate. A different view explains that it runs up into the body, fixed on to the jaws, and that it supports some projections called "true teeth." There are five of these jaw arrangements, each of which is called "an angle," and the roots, so to speak, of the arms fit in between their bases between neighbouring mouth shields. (Figs. 2, 4, 9 *d*, jaws; *e*, teeth; *e p*, jaw plate).

The arms, whether long or short, spiny or nearly plain, are composed of an outside of more or less regular plates, and of an inside support. They must be tolerably strong, more or less protected, able to move, and, oddly enough, capable of being separated here and there, and cast off, to be again repaired. Their conformation relates to the habits of the animal, and as some Ophiurans wriggle them much horizontally, and indulge in serpentine and interlocking movements wonderful to behold, they must have the scales on the arm arranged to permit of this, especially as in these instances long spines stick out from the sides of the arms. Such arms are of necessity not capable

of much upward or downward movement. It is somewhat remarkable that although many of the species have arms many times longer than the bodies are broad, and they seem to be of the greatest possible importance to them, still they are not only readily broken by accident, but even cast off joint after joint, piece after piece, until only the body is left. These kinds have the very good name of Brittle Stars. Other Ophiurans have small spines on the arms, have not so much horizontal and about the same amount of vertical movement as the others, and their power of casting loose their own segments is less. These are the Sand Stars. Both kinds have the arms in numerous joints, each of which consists of four plates. One is above—the upper arm plate; one is below—the lower arm plate; and one on either side, and encroaching more or less above and below (or not at all), the two side arm plates. The plates get smaller and smaller towards the narrow tip of the arm, and the whole member consists outside of a repetition fore and aft of these four plates. Sometimes skin exists instead of some plates or parts of plates, and the successive plates are united by skin to their neighbours. The plates are not very thick, and form, as it were, a tunnel, wide, close to the body, and narrowing at the tip, where it is closed. There is a central support running down inside the arm, which can be seen when an arm is broken across, and certain openings in the arm outside have to do with it. The openings are on either side of each lower arm plate, and between it and the side arm plate on either side, and they are for the passage outwards from within of feelers or tentacles. The arms are flat below, where covered by the lower arm plate, rounded, and more or less tall at the sides, where the side arm plates and the spines are, and rounded or roof-shaped above, from the presence of the upper arm plates. It must be remembered that the tentacles come out below at the sides of the lower arm plates; and they are protected by a little scale or scales, which may be on the side arm plates, or on the lower arm plates, or on both. On looking at the mouth of a living Ophiuran, four longish tentacles will be seen in each slit which is between two mouth angles, and two belong to the jaw of each side of each angle, so that every jaw has four, or two on either side. One is higher up in the jaw than the other, and they are protected by tentacle scales more or less large. (Figs. 4, 9.) The passage between the teeth leads to the stomach. One of the group in lively movement is a sight to see; the muscular energy is marvellous, and this is especially the case with the Brittle Stars. A Sand Star may be seen crawling over things in the aquarium, moving its arms not very much, but using the numerous pairs of short active tentacles a good deal. They have no suckers at the end, and they are not attended by care-

ful pinching pedicellariæ as in the Urchins and Starfish. They do not help the star much in climbing up glass or weed, but they appear to be extremely sensitive to touch, to the presence of foul water, and of nice things. The large tentacles of the mouth angle spaces move much, and evidently direct food to the mouth, and when a soft bit of oyster is given to the animal, it being permitted to touch one of the arms, this is moved towards the mouth, and the mouth towards it. All the tentacles are expanded to the utmost, and the morsel is pressed against the mouth and gradually disappears, the opening between the teeth becoming slightly wider; after awhile, the part of the food which cannot be digested is returned. They know what is nice, and can therefore taste; they are vivacious after a good meal, and therefore digest comfortably; their tentacles enlarge and contract, and the arms and body grow, therefore there must be a circulation and processes of nutrition. They have more than a rudimentary nervous system, but eye specks or visual organs are deficient. They soon die if their respiration is not well kept up; and as this is mainly done by the tentacles and their internal machinery, a curious self-mutilation accompanies impaired respiration. The arms are cast off at joint after joint, as the water becomes more and more impure. The Brittle Stars drop their arms, which continue to wriggle for a time very readily; and the process of repair seems to be pretty rapid, for new arms or pieces soon grow again.

It is now necessary to consider some points in their anatomy and physiology a little more closely.

If the skin and scales of the middle of the upper part of the disc be carefully cut through and raised with a pair of forceps, a membrane will be found beneath them, and attached pretty firmly in some places and less so in others. The membrane is the upper part of the stomach; and if it be opened, the inside of the organ is seen, and quite low down there are five whitish bodies projecting inwards towards a common point (fig. 5, *d*, *e*). These are the upper five teeth, one on each jaw, *e*, and the upper surface of the jaw plate and jaws is seen (fig. 9, *e*, *ep*, *d*). An opening exists between the approximating teeth centrally, and it leads to the lower surface of the animal, or to the lower opening of the mouth. The teeth stand out well, and the membrane of the stomach is not attached to them, for it encircles the whole jaw arrangement a little further out than the attachment of the jaw plates to the jaws (fig. 5, *s*), and passes over the space between the angles. The stomach is in the shape of a wide-mouthed bag, which has no other opening than that of the so-called mouth, and it does not fill the body, nor is it, as in the star fishes, found in the arms. It is attached to the under surface of the skin of the upper part of the

body, and also along the circular line on top of the jaws, and this last adhesion is not broad but almost linear (fig. 5, *s*).

Leathery in spirit and water, its structures are not then readily distinguished; but a fresh Ophiuran's stomach membrane is semi or quite transparent, and yields some interesting points to the microscope. There is a muscular coat, consisting of sets of separate fibres, unstriped and sometimes branching, which radiate from many centres. Those of one locality join on to those of another, and form a series of close meshes. The fibres are distinct, delicate, and are outside a mass of cells, which are spread out as an indefinite membrane, and are ciliated. The cilia are numerous, small, and are readily cast off with their cell. It would appear that, although the lower limit of the stomach around the mouth within, is an irregular circle made by the jaw plates and the sloping sides of the jaws (producing five re-entering festoons and loops external to the jaw plate), there is a film of probably ciliated membrane passing down between the angles to the surface. But really the entrance to the stomach is central only, and not also between the side of each jaw angle. The teeth form five buttresses around the opening. The large tentacles in each angle are muscular, tubular, and ciliated, and they come out of the jaws by holes, one of which is nearer the stomach than the other. They fill up the angle greatly, and as they move radially, they assist the food in entering, and expel undigested matters, and, as Forbes wrote years since, they are in constant movement. Water passes readily into the mouth and stomach, when the teeth, set in longitudinal series on to the jaw plates, are slightly removed from each other (fig. 7, *e.*); but when they touch by their points the passage cannot be free. The question arises—Do the vertical true teeth act as chewers? By what structures do they approach and regress in order to chew? Mr. Lyman calls the five angles of the mouth and the supported teeth the chewing apparatus. We distinguish between biting, masticating, and chewing: the last term relating especially to the particular lateral movement used by mammals, and to a constant movement, in which the teeth are not much separated, and which is used by man to enjoy tobacco.

There is evidently no lateral movement in the angles of the jaws, and that which is directly to or from the central or axial line of the vertical mouth, must be very slight. It would appear that the jaw plate is made up of more than one piece, although this is by no means always to be seen, and the teeth which it supports on its inner face (figs. 9 and 7, *e*) are said to be connected to it with muscular fibres. Microscopic, indeed, are they, and they can only relax and contract and fix the teeth laxly or rigidly to the jaw plate. Their power of assisting biting

or crushing is hypothetical. The tooth papillæ (fig. 4, t.p.), which in some genera form a symmetrical group close to the lower margin of the jaw plate, merge gradually into five teeth above. They cannot act as crushers, and indeed in many species those of the five angles are widely separated below, so as to form a funnel-shaped opening to the mouth, leading to the narrow space above, where there may be only two or three teeth on each plate (fig. 4). Lately Danielssen and Koren and myself have described species in which the true teeth are divided, pointed, and irregular, and yet the Ophiurans were invariably large and well nourished. There is no rule about the closeness or open condition of the mouth canal between the jaw angles after death. In some specimens the teeth are in apposition, and the mouth papillæ (fig. 9 *m.*, *p.*), nearly close the sides of the angles; but in others it gapes and *rigor mortis* fixes it slightly open. Moreover, small Lamelibranchs, as I have lately had an opportunity of finding, get into the stomach, but their delicate valves are not crushed; and Foraminifera are to be found there, comparatively uninjured, besides much mud. The masticating and chewing does not take place. The mouth papillæ, situated on the sides of the jaw angles (fig. 9, m.p.), are evidently filterers, and so are the tooth papillæ. The true teeth keep out trespassers from the stomach, but none of them are used to crunch or smash nourishment, and the wonder is how the creatures manage to poke good-sized pieces of oysters into their mouths. The tentacles within the angles are of immense importance in this proceeding, and it is very conceivable that the usual and normal food is finely triturated mud, containing minute organic bodies. It is clear that in some species the moving outwards of the jaw angles from the axis must be of the slightest description; for the mouth apparatus is rendered unyielding in them, by the side mouth shields being united under the arm in a continuous zone. On the other hand, some extra limit may be granted by the non-union and generally rudimentary condition of the side mouth shields in some genera. Possibly some movement of the jaws towards each other centrally, may occur, first above and then below, and it is conceivable that movements of the arms from side to side, and from above downward, rare as these are in some kinds, must contribute to slight movements in the jaws. Some kinds, however, keep their teeth closed in spite of great wriggling. In fact, the more the matter is examined into, the more difficult it is to understand, not only how the Ophiuran bites and chews, but how it bolts a morsel; and certainly it does this last performance, whatever doubt there may be about the first. The stomach has some fibres, both longitudinal and circular, and some are close to the line where it is attached in festoons, above and external to the

teeth; and the animal, when it gets anything eatable near its mouth, probably relaxes its stomach muscles, and stuffs the morsel down with its arms and mouth tentacles. They must, in some instances, swallow mud in large quantities—mud containing organisms with calcareous shells, and I have found Foraminifera in the stomach. Forbes,* in noticing the result of digestion, writes with regard to the tentacles: "They are continually in motion, moving up and down; and every now and then when the stomach pouts up and ejects some digested matter, the inner tentacles shovel it up, and the outer clear it away. This is done with great regularity, and it is a very curious sight, for not only are the motions and actions of the tentacles admirable; but when the stomach swells, there appear bright orange stripes of a most vivid metallic lustre running along its surface with an almost phosphorescent gleaming." These remarks refer to the common Sand Star.

The ciliated surface of the stomach is secretive also, and from it must come the weak acid juice which dissolves the protoplasm and organic matters of the food, with some pepsin or other. The corroding influence is seen in the minute shells found in the stomach, and thus a digested pabulum with some salt of lime is manufactured. It is destined to nourish the animal's soft and hard parts to the remotest arm tip, to replace albumen and fibrine, refractive matter, chitinous fibre, and worn-out carbonate of lime of the skeleton, and to be placed in definite positions during growth. It has to be circulated everywhere, and the worn-out matters have to be got rid of from the tissues. Substances which cannot be digested are of course simply removed through the mouth; and as perfect closure of the mouth cannot prevail for any considerable length of time, much water must find its way into the stomach. Doubtless the chyme, if it may be so called, is much diluted, and it is wafted over the inside coat of the stomach over and over again by means of the cilia, but, beyond believing that it may enter stomach cells and pass from one to another, the imagination fails to assist in the elucidation of the problem, especially if it is centred in the belief in veins, arteries, and lymphatics as inevitably necessary physiological adjuncts to nutrition. Some amount of churning may go on in the stomach during digestion, for the muscular fibres are numerous, and are of the kind which is associated with involuntary rhythmical movement; and this alternate contraction and relaxation may assist in the movement of the nutrient plasma in and through the cells. The process must be of the simplest kind, and this is an important consideration, for digestion is much more complicated in the Echini and Star-fish, which are associated with the Ophiurans in classification.

* Forbes, "A History of Star-fishes," p. 24.

There is a plan which I have adopted in investigating the rough anatomy of the Ophiuræ, which may be of use to other investigators, especially if they have time to follow out the structural details which are rendered manifest by it. Get a small specimen of *Ophioglypha*, and put it in weak hydrochloric acid and water, 1 in 100 at first, and then 1 in 20, washing often in clean pure water. Too much bubbling must not be allowed, for it destroys the tissues, but if the solution of the carbonate of lime proceeds steadily and slowly, a very remarkable preparation may result. It is difficult to get rid of all the carbonate of lime, especially from within the arms, but sufficient may be dissolved to give capital views of the anatomy.

One detail soon becomes evident on the under surface of the animal, and that is the lower limit of the stomach. Turn the preparation on its proper upper surface, and examine the lower by transmitted light, and a wide circle of tissue is seen hidden more or less, by the transparent tissue which was once jaws. It fills up the slits between the angles nearly to the level of the jaw plate, and there is no passage there into the side of the angle. On this lower surface of the stomach, or in the proper position of the animal under it, but close to its attachment to the jaws, is a canal or tubular membrane. It can be seen to give off branches, and to make its way as a microscopic tube into the arms, running in the median line on the under surface beneath the lower arm plates, which are of course all dissolved away, so far as their mineral part is concerned. It is a circular tube surrounding the insertion of the stomach into the jaws at a little distance and branching for every arm. In a little *Ophioglypha*, the body of which is less than $\frac{1}{3}$ inch across, the tube is about $\frac{1}{300}$ inch in diameter after the acid treatment. The tube has swellings on it called Polian vesicles. In the instance before me, a short membranous tube leads from the perforated or madreporic mouth-shield to a globose enlargement, whose diameter is five times that of the tube, and a corresponding tube makes its exit on the other side and then slants off to the circular tube, which it joins. This is the feeder with water, from without; and in its passage from the mouth-shield to the circular tube, it runs upwards and slightly inwards between the root of two arms and outside the stomach membrane, and between it and a membrane about to be considered, and which has to do with the reproductive organs. The swellings or Polian vesicles on the circular tube, usually said to be four in number, are simple enlargements of its muscular walls, with a slight increase of calibre on one side of the axis of the tube, and they are found close to the position of the off-giving of the radial vessels of the arms. In the specimen of *Ophioglypha*, the tube is pentagonal and not circular in direction,

and the swelling on the madreporic tube, replaces the fifth Polian vesicle. The whole is as unlike the drawings given in text books as is usual in cases where a diagram is reported to be a truthful representation of nature. Moreover the canal is closely invested by other structures, and when full and in action must have contained a very minute quantity of water. It is said to have an internal cellular layer which is ciliated, and one can envy the eyes which saw this very probable fact.

Between this more or less circular canal and the circular attachment of the stomach, is a ring of nerve which rests on the jaw close to where there is a suture or join between the stout or inner part of the jaw and the narrower portion, to which is attached the jaw plate. As a matter of fact this nerve is external to the stomach attachment and slightly above it, and it is internal to and below the circular tube. What modifications age may make I do not know, but that is the position in the young.* The closeness of the water- and nervous systems is of importance, especially if the circular tubular canal acts as a blood circulator as well, which is excessively probable. In order to understand the course of the branches of the circular water canal, a few words must be said about the jaws, to which allusion has been so frequently made. As already noticed, their under surface is seen internally or orally to the side mouth shields, and two are placed together in each angle, their sides supporting the mouth papillæ and their inner end the jaw plate and its tooth papillæ and teeth (figs. 4, *d.*, 7, *d.*, 9, *d.*). The upper surface can be seen by removing the skin of the upper part of the disc and opening the stomach (figs. 5 and 9). The jaw plate and its teeth are seen to be attached to two rather diverging pieces, and these are the upper part of the pair of jaws of the angle, rather separated externally. Still further out, the separation increases, and an irregularly triangular piece is connected internally with the short diverging jaw, and is called the jaw or mouth frame. The mouth frame, one to each jaw, unites on one side with the mouth frame of the jaw of the next angle, and on the other, does not unite with that of its fellow jaw of the angle, but a space exists. The united mouth frames are in contact externally with the first plates of the arm, and the vacant space between the frames of the jaws which coalesce within, is in relation with the cavity of the body which is outside the stomach—the generative cavity. The arm, then, springs as it were from the union of the outer parts of the

* Edward Forbes described the nerves of the Daisy Brittle Star, and noticed that there were no ganglionic enlargements, and he stated that each arm was supplied with two pairs of nerves from two sets of the main division.—*British Star-fishes*, c. viii. 41.

jaws of two angles, or, in other and more correct words, the jaws are modified arm-endings, being composed of two arm joints, the inner one of which is bent down so as to be lower than the other.* If a side look can be got at a jaw angle (fig. 9), by cutting an Ophiuran across the body along the line of one of the arms, the jaw will be seen to be deep and to extend very visibly from above downwards. On the side, are two holes and two scales or scale-like spines, an upper and lower, and they are for the upper and lower mouth tentacles. These long, slender, fleshy, hollow bodies come out through the holes, and their tubular cavities are continuous with the circular water canal, or rather with an offshoot which makes its way to the arm, passing obliquely downwards and outwards to reach a groove, which, in the natural position of the Ophiuran, is just above the lower arm plates in the body of the arm and in the median line. As each of the five main branches passes off from the circular water canal, close to the rim of the stomach membrane, to reach its special arm, the side branches for the first two tentacles are given off, one after the other. This dipping downwards and outwards of the main branches, is accompanied by a similar distribution of nerve, and the nerve cords cling to the water systems, being enveloped in fibrous tissue in a common sheath. Every tentacle in the arm has its offshoot from the radial vessel, and it is short and ends in a *cul de sac*, the tentacle not being open at its tip. There is no mechanism to produce a sucker, and those organs are wanting; consequently there are no extra contractile sacs associated with the tentacles and in connection with the water system, as is the case in the Star-fish. The radial water canal passes, then, along each arm, associated with nerves, and at each joint a water tube and nerve are given off, on either side, to the tentacles. Probably the tentacles have something to do with respiration. The arms, as already noticed, consist of a series of four plates, united more or less closely by skin, and there is an opening at each joint or cale on either side inferiorly and between the side arm plates and the lower arm plate. The member thus enclosed in armour in many genera, and having much visible skin between the plates in others, has an internal skeleton, the explanation of whose ancestry defies the most imaginative biologist. It is a structure *per se* in the Echinodermata, and is as elaborate a piece of mechanism as can well be imagined. The use of it is evident enough, and there is some correlative relation between its elaboration and that of the side arm plates. That is to say, in those genera where the

* There is a capital diagram of this by Theodore Lyman, in "Ophiuridæ," &c.—Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass. Vol. iii. No. 10.

side arm plates do not encroach, over-much, upon the upper and lower surfaces of the arms, the internal skeleton is well developed; but where the side arm plates form a large portion of the arm, then the elements of the structure inside are feebly represented. They are not wanted, for a dense squamose covering capable of but slight movement exists. But when the ordinary mobility of the arm from side to side and a little of an extraordinary kind from the horizontal downwards are possible, and the outside plates are not too close or rigid, then the long line of ossicles inside each arm is perfect. The resemblance of the inner skeleton of the arm to the vertebræ of the higher animals is, of course, only superficial, but nevertheless some of the methods by which vertebræ are joined together in the Ophidia and mammalia are foreshadowed in it. On breaking the arm of an Ophiuran across, near the body where one joint is connected to another, that is to say, between two consecutive lower or upper arm plates, the central part is seen to be filled up with a rather complicated structure or ossicle, which presents two surfaces. One, seen on the broken face of the arm left attached to the body, is the external, and another, on the separated piece, is the internal, and they fit one on to the other and are joined during life by muscles. The contour of the ossicle of each joint, conforms to the outline of the arm, in transverse section, and its length corresponds to that of the outer plates. The ossicle adheres by the agency of fibrous tissue and muscle to the upper arm plate above, and to the other plates in their proper positions: but it has a decided groove on its under surface in the median line, and this is turned into a canal by the contact with the upper surface of the lower arm plate. A smaller groove is noticed above, and is beneath the lower surface of the upper arm plate. These two grooves are in a vertical line which would separate the ossicle into halves, and the lower one contains the extension of the water system and nerve from within the body. The surface of each ossicle has certain knobs and pegs, cavities for their reception, and broad spaces for muscular attachments. Thus the inner surface has rather above the middle, yet centrally, a broad projecting knob, and near the lower edge two smaller knobs, one on each side of the median line, in which and between them there is a depression or socket. On the external side of the ossicle three cavities exist, which correspond with the knobs, and they fit them, and there is also a peg which fits into the socket in the other ossicle. Rotation or twisting of the arm is thus prevented, and also too much up and down movement, whilst some latitude exists for side to side motion. Considerable surfaces exist on both faces, into which muscles are fixed, and there are muscular fibres on the outside of the ossicle attaching it to its fellows before and behind.

On looking at the top of an ossicle, underneath the upper arm plate, the small groove is seen, and on either side of it a broadish angular flap on which the upper arm plate rests and which is the homologue of the mouth or jaw frame. Internally there is a concavity for the reception of the peg of the next ossicle within, and externally is seen the peg itself. The lower surface of an ossicle shows the large median groove for the water tube and nerve, and there are two marks, one on either side, where the tentacles rest as they pass outwards to the surface, and also the peg and socket in their relative positions fore and aft.

There is an offshoot of the water tube and nerve to each tentacle, and there are nervous filaments crossing the muscles which are on either side of the median pegs and holes. The decalcification of an arm in a small specimen will render the vessel and nerve visible, and it appears that they are enclosed in rather thin fibrous tissue, the nerves being numerous, excessively delicate, with numerous nuclei, and they surround the water tube. (Fig. 8 *x*, *y*, *z*.) This is cylindrical, but it swells at the joints of the arm plates where the branches are given off, and its walls are thick, transparent, and sparely nucleated. (Fig. 8 *z*.) The muscular fibres are unstriped, and most are simple; but many are compound and branch and unite, forming a plexus. Many extremely delicate and narrow fibrils wander about the muscular fibres, and probably they are nerves. Moreover the impression remains on the eye, that there is an opening at the joint between the meshes of the muscles and the water tube, as if the fluid could pass into the tissue.

In the instances where the plates of the arms are not well developed, as in the genus *Ophiothela*, whose species cling to Isidinæ and even to other Ophiurans, and in which skin and grains of carbonate of lime almost replace the plates, the ossicles are still developed. The arms are of great importance, and they form, by a morphological metamorphosis, the jaws and teeth and support the nervous and vascular systems. A few words must suffice to notice the spines of the arms. They are situated on the side arm plates, and on the front, free outer margin: they are close to the side and point along the arm in Sand Stars, which have but slight lateral movement in the arms; and they project more or less at right angles from the arm in the other Ophiurans. Those bristly-looking arms, characteristic of Brittle Stars, are competent to move and wriggle sideways to any extent. Exquisitely beautiful are some of these spines, and especially when they are of a glassy transparency. They frequently move on a rough ball and socket-joint, and are often numerous and even crowded, or are placed in one row. Besides these accessories to the side arm plates, there

are scales and spinules on them close to the tentacular openings. These are small and broad as a rule, single or multiple, and occasionally, some are on the lower arm plate. Their duty is to protect the base of the tentacles. A third kind of spine is noticed in the small group of Ophiurans which clasp by bending their arms downwards. These spines are really hooklets, with two or more sharp recurved brilliantly transparent teeth, and the side arm plates resemble flaps stretching out from the arms more than anything else. Similar, but less elaborately ornamented, hooks are found in many Brittle Stars, and usually the spine next to the tentacle is thus formed. Some Sand Stars, such as *Ophioglypha*, have a hooklet near the end of the arm instead of one of the spines, and Mr. Percy Sladen has found them in our North Sea forms.

Almost every naturalist has read Edward Forbes's account of the spines of the Thread-rayed Brittle Star, which lives in soft slimy mud. Its third spine on the side of the joint is the largest, and instead of tapering to a point like the others, is furnished at its extremity with two transverse-curved spiny processes, giving it exactly the form of a pickaxe. Forbes considered that the arrangement would be useful in working about in the mud.

The arms are readily cast off, in different places, in many species of Ophiurans, and often the disc alone may remain, the extremities wriggling for a while and dying, and the disc hoping to grow its arms again in time. Reparation is almost as certain as the mutilation. The Brittle Stars are extremely apt to break, and hence their very appropriate name; but it appears that in perfectly comfortable circumstances one of them should and can carry its arms out of the battle-field of life safe and sound. Foul water, fright, what might be called in higher animals hysteria, and accident, produce breaking in bits, or the whole arm is cast, and the only way in which the process can occur, is by dislocating the system of pegs and sockets of the ossicles. Too great bending of the arm upwards, brings the lower peg out of its socket, and then there is a stress on the large upper one. The least excess of action of one set of side muscles over the other, will carry the ossicle out of its axial position, rupture the water system and nerves, and then the next motion of the joints nearer the body, will separate the structures.

It is necessary, in conclusion, to notice the reproductive organs whose position is in the body around the stomach bag, and external to and above the water tube and nerve ring. On turning the Ophiuran on to its proper upper part, and then examining the body close to the arms within the disc, slits will be seen parallel with them; in some genera there is one on each side of the arm on the body, and in others there are two, one

before the other. These have often granulations or spinules on their edges, and may be short or long. (Fig. 10 *g*, 2, 6.) A needle placed in one goes into the body, and if pushed on, will come out at the top through one of the ten large plates which are placed there close to the upper edge of the arm and on one side. These are the radial shields. (Fig. 1 *a*.) If the needle is pushed inwards towards the mouth it will be stopped beneath the mouth shield on the under surface by the jaws as they pass inwards and sidewards from the arms: and if the instrument is pushed in the opposite direction it will be stopped by the inside of the edge of the disc. In fact, there is a space which is thus situated outside the stomach and jaw apparatus and beneath the shields, and it may be subdivided into ten, two in each interbrachial space, or there may be a greater or less general cavity extending from one arm space to another over the arm, forming a marsupium or pouch. In the spring time, the spaces are crammed and the disc is swollen with ova, red in colour, and there may be masses of white, which are spermatozoa. They are in and amongst much connective tissue forming a set of bags. Water passes readily through the generative slits into the chambers, and at the proper time the ova burst forth to pursue a very remarkable metamorphosis. Years since, living and perfect tiny Ophiuroids were found in the pouch of the parent, and there is no doubt that then the ova are hatched within, and that the metamorphosis is skipped.

DESCRIPTION OF PLATE VII.

Fig. 1. The upper surface of a Sand Star, *Ophioglypha Sarsii*. *a* = A radial shield.

Fig. 2. The under surface of the same Ophiuran. *b* = a mouth shield. Generative slits by the side of the arms.

Fig. 3. The side of the arm showing (*u*) upper arm plates, and (*m*) side arm plates, carrying spines and minute tentacle scales.

Fig. 4. View from below (in the proper position of the animal) of a jaw angle in a species of Brittle Star, *Ophiothrix*. *d* = a jaw; *c* = a side mouth shield; *b* = mouth shield; *t p* = tooth papillæ and at their end some teeth. The oval with the tooth papillæ is aslant, and on a higher level in the natural position than the jaws *d*. A tentacle (*q*), the lowest of the angle, is seen on each side close to the side arm plates.

Fig. 5. View from above of ends of teeth and jaws; the curved line marks the attachment of the membrane of the stomach, and external to it would be the position of the nerve cord. *e* = teeth; *e p* = tooth or jaw plate; *d* = jaws; *s* = stomach line. The dotted lines note the line between the jaws.

FIG. 6. The under surface of a Brittle Star. *Ophiothrix.*

FIG. 7. The side view of two jaws with their teeth, the space between leads to the stomach above and mouth below, in a small Sand Star. e = teeth; d = jaw.

FIG. 8. Water canal and nerves of arm, removed from the fibrous canal or sheath. x = a plexus of nerve fibres on the water tube; y = water tube; z = a nerve on a portion of the water tube. Magnified with a quarter-inch object glass.

FIG. 9. An oblique view of the jaws and other plates of the mouth after Lyman; d = jaw; c = side mouth shields; b = mouth shield; $m\,p$ = mouth papillæ; e = teeth; $e\,p$ = jaw plate. The upper and lower tentacles of the angle are indicated by dotted lines, and their scales are at their exit from the sides of the jaw.

FIG. 10. The relative position of the mouth shield and the generative slit; g = slit; c = side mouth shield; b = mouth shield.

COAL AND COLLIERY EXPLOSIONS.

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FRINGING the coasts of a large portion of Britain are lines of raised beaches, submerged forest beds, and inland tracts of peat, resting on marine and estuarine deposits, indicating a succession of elevations and subsidences, characterized by periods of vegetable growth, alternating with still longer epochs of deposition. Nowhere, perhaps, can this sequence be studied to better advantage than in the lowlands lying between the Mersey and the Ribble, and nowhere could be found better examples of the probable method of formation of the various measures and coal seams of the adjacent West Lancashire coal field. Careful examination of all the thicker coal seams show them to consist of distinctly stratified vegetable matter separated into groups by earthy partings, which vary in thickness, even in different parts of the same colliery, and which, when followed to a considerable distance, are often found to not only expand, but to be associated with other sedimentary material, so that the two layers that form one coal seam at the first point, become separated into two distinct seams in the more distant area.

An exact parallel to this may be found in most of the Lancashire mosses, thin planes of grey clay traversing the centre of the moss, gradually expanding towards tracts where the water was deeper and currents brought in foreign material, until the basin-shaped hollow was filled up, and the growth of peat went on.

All who have studied geological sections, especially in their relation to the structure lines of scenery, will have noticed the tendency valleys have to occur along lines of anticlinal axes; while the synclinals, or inward dips, constitute planes of strength which are noticeable in nearly all our hills of all geological ages, and especially in those which have longest withstood the wearing and degrading action of later denudation. The coal fields are, however, a noteworthy exception to this, for though

seldom rising into hills, they are almost invariably found in a basin, which can be proved in many cases to be a *synclinal* not merely of subsequent movement, but of contemporaneous deposition. In other words, the vertical distance between two given coal seams or other horizons is greater in the centre than on the edges of the coal basin; the thick coal seams of the circumference of the area have divided finger-like towards the centre, where the land was subsiding at a quicker rate, and the intervening space has been filled in by sedimentary material, deposition keeping pace with the rate of subsidence, so that the uppermost coal seam covering the whole is contemporaneous over the whole area. The Staffordshire thick coal, splitting into so many seams, is perhaps the best example of this. In the Newcastle field there is a thinning and splitting towards the centre of the coals, and thickening of the sediment. This is also the case in Lancashire, the measures between the Arley and Ince Yard coals thickening towards the centre of the basin 66 feet per mile for each mile traversed, or from 1,500 to more than 2,300 feet. And here the remarkable fact works out that at the time of the formation of the Arley seam the rate of subsidence was the same over the whole field; but a little later in time an axis of greater subsidence came into being, which gradually travelled to the north-east during the deposition of the whole of the middle coal measures, until it reached the district around Wigan—the area where the celebrated Wigan cannel is of greatest purity and thickness. Here vegetable matter would reach its most complete condition of maceration, and here the cannel-coal vegetable matter in the most extreme state of comminution is thickest. Associated with the cannel are the scales of large fishes, which, salmon-like, swam through the water from the more open sea. With the cannel and at various other horizons in the coal-field are thick seams of *Anthracosia* shells, near to our freshwater mussel. Whether they represent it or the estuarine condition indicated by the *Scrobiculariæ*, which so constantly occur in the grey clays intercalated with the Lancashire mosses, is still a moot point with naturalists.

The character of the trees found at the base of the Lancashire mosses varies with the nature of the underlying soil. Generally the roots penetrate the grey estuarine or fresh-water clay beneath, resembling much in appearance and chemical composition the underclay of the coal measures, containing the stigmaria-roots of sigillarian tree trunks, found broken and scattered in the coal and shale above, just as the trees found in the mosses have been broken off at a certain distance above the ground.

Through obstructed drainage, water has accumulated around

the trunks in both cases, leaves have fallen around the trunks, bog and morass have formed, cutting off all supply of oxygen from the roots, the gas which forms so essential a constituent of the sap, and without which the tree cannot live; the decomposition going on, the fallen vegetable material must have robbed the soil of its oxygen until all the iron in it was reduced to protoxide, and an effectual barrier to the entrance of all fresh oxygen produced: no less than 4·73 per cent. of protoxide of iron being found in fireclays by Dr. Frankland. After the death of the trees, the trunks appear to have been snapped off by prevalent winds along the line of junction of water and air, and both in the coal measures and in the mosses there is generally a determinate direction in the lie of the trunks. The growth of peaty material gradually covered up the trunks, and subsidence placing the surface beneath the water level, the whole became covered up with sand and mud, borne by currents which occasionally have completely cut out the coal seams, since filled in with sandy material forming the "rock faults" of the miner.

Through subsequent pressure the coal has obtained an elaborate system of jointing, which maintains an average general direction over extensive districts, but differs in different coal-fields, doubtless running parallel to the main lines of movement which traverse the district, some of which have again brought the coal-field to the surface, or to comparatively short distances beneath the cover of underlying rocks.

Bischoff, Graham, and Playfair have shown that the gases evolved by coal contain from 66 to 94 per cent. of light carburetted hydrogen, and that nitrogen is always present, sometimes amounting to from 14 to 21 per cent. of the entire volume, which can only be explained by "supposing that air has permeated the fissures of the coal and, acting upon it, has been robbed of its oxygen, partly by union with hydrogen, partly with carbon."

The process of decomposition of the coal is still going on under conditions of considerable pressure and tolerably high temperature; the elimination of carburetted hydrogen, carbonic acid, and water, forming the much-dreaded "fire damp" of the collier, is the result. It will be remembered that the composition of our atmosphere in a state of purity is, in 1,000 parts, 788 nitrogen, 197 oxygen, 14 moisture, and 1 carbonic acid, combined mechanically, and that an adult vitiates a cubic foot of air a minute. Then the capacity of the air for holding moisture increases with its temperature, holding 2 grains per cubic foot at 30° F. and 7 grains at 70°.

The ventilation of a colliery has not only to provide a fresh supply of air to replace that vitiated by the colliers, each of whom exhales 6·3 gallons of carbonic acid hourly, but has to be of sufficient strength to sweep away all inflammable gases issuing

from the coal. This is effected by having two shafts, and by placing at one of them, which forms the upcast, either one or more furnaces in the different coal seams worked, or a revolving fan at the top of the shaft, which extracts the air in the workings.

Forty years ago no mechanical means were in use for measuring the velocity of currents of air passing through a mine, the rate being then ascertained by carrying a lighted candle exactly at the same rate as the current, so as not to deflect the flame, which method is accurate up to velocities of 400 feet per minute, but is not applicable to the principal splits of large collieries of the present day, in which the speed of the current would require a person to run. Another method that is still used for measuring its velocity is watching the time gunpowder smoke takes to travel over a given measured distance, of which the sectional area is known.

The first anemometer was invented by Mr. Thomas Elliott (a brother to the present baronet, Sir George), in 1835, and was worked by "the air acting on four wands, similar to a windmill, which met so strongly with the approval of the coal-owners" that they presented him with ten guineas; but they did not adopt it in one of their mines.

Anemometers that have since been constructed belong to three classes:—

(*a.*) Vanes revolving by impingement of the current of air, registering rate by a pointer, as Combe's, 1837; Biram's, 1842; Whewel's, Osler's, and Robinson's.

(*b.*) Instruments not revolving, but affected by the force or impulse of the wind, as Dr. Lind's, Henaut's, Bougier's, and Dickenson's. The latter consists of a light, counterpoised, flat fan plate, usually made of talc, being on two fine bearings. The plate moves up an arc, graduated in feet, which gives the velocity per minute, which, multiplied by the area, gives the cubic quantity.

(*c.*) Those of a more complete character, as Leslie's, in which the velocity is deduced from differences of temperature.

An ingenious application of the telephone, to test the state of the ventilation of a mine without a descent being made, was tried last year on the Wigan and Whiston Collieries, by Mr. Hall, H.M. Inspector of Mines, in the presence of Sir William Thompson. One of Biram's anemometers, generally used in collieries to detect the velocity of the air, was attached to a telephone, in which a small thin iron box was substituted for the ordinary diaphragm, which vibrated at every tenth revolution of the anemometer; this was taken down the shaft and main intake and connected with a telephone in the office on the surface, by 600 yards of ordinary coated electric wire. The

vibration was distinctly heard, giving 28 beats a minute, or 280 revolutions, which, multiplied by the area of the roadway, gave the quantity of air passing.

Fire-damp mixed with air in the proportion of 1 to 4 produces drowsiness when inhaled, and when increased to 2 to 1, suffocation follows. When it only forms $\frac{1}{30}$ to $\frac{1}{15}$ of the whole volume, the flame of the Davy lamp increases and gradually enlarges, and becomes surrounded by a pale blue halo, or "cap," as it is called by the colliers. When $\frac{1}{9}$ or $\frac{1}{8}$ of the volume is fire-damp, the mixture is highly explosive; and with $\frac{1}{3}$ a lamp will not burn for want of oxygen.

The Davy is used as a sort of gauge to determine the presence and quantity by the colliers, and especially by the "fireman," whose duty it is to examine the colliery before the men enter, for gas, as well as to fire their shots, during the day. The lamp is held close to the roof, and gas is indicated by the blue cap; but the whiter the flame, the quicker it fires; if the flame elongates, or flutters, it is gently drawn down so as not to be allowed to fire. If the lamp fills with flame, and continues burning, the collier pulls down the wick with the "pricker," and endeavours to extinguish it by plunging it into water, covering it with a woollen jacket, or dust and *débris*. If it cannot be extinguished, an explosion results.

A Davy lamp is constructed of parallel iron wires, twenty-eight crossing each other in a square inch, leaving 784 apertures to each square inch of surface: when the gauze is new, or covered with oil, and raised to a red heat, it gives off inflammable vapour, which will ignite at that temperature, but this is only the case when the heat is applied from the outside, which is almost impossible in practice.*

Professor G. Forbes has just described, at the British Association Meeting at Dublin, an instrument for determining the quantity of fire-damp in mines. It consists of a metal tube resonator, one inch diameter, and 15 inches long, in which a

* Other experiments made by the North of England Institute of Mining Engineers show that "an inflammable mixture of pit gas and air, moving at the rate of 8 feet per second, will explode against a stationary Davy lamp without a shield," and at 12 feet with a shield, at 9 feet with a Stephenson lamp, or with a Clanny lamp.

The comparative illuminating power of these safety lamps, using a wax candle, six to a pound, is as follows:—

	Average number of lamps required to equal a wax candle
Davy's lamp	8·00
Stephenson's lamp	18·50
Clanny's (glass)	4·25
Mueseler's (glass)	3·50

piston slides, and a tuning-fork of definite pitch attached to a block of wood, to which is fixed the tube. The tuning-fork is sounded, and the tube moved out, until the proper length is found, which is indicated by the resonator intensifying the sound of the fork. A light gas requires a longer resonator, and the density of the gas can be read off the scale, and two per cent. of fire-damp mixed with common air, it is said, can be detected.

The writer of this paper has recently, in letters to the *Times* and *Colliery Guardian*, suggested still another means of detecting the presence and volume of fire-damp. Taking advantage of the well-known and, to the miner, disagreeable whistling or blowing of gas issuing from the pores of the coal, he has suggested that a telephone (or microphone) be placed against steady blowers of gas, and that these receivers be connected with deliverers in the colliery office, which might be made to speak to a phonograph, automatically worked by clockwork, so that a continuous record of the quantity of gas evolved from these given test points might be kept and studied above ground.

When it is remembered that the weight of the atmosphere balancing 30 inches of mercury is 2120·25 lbs. on each square foot of surface, and that a fall of one inch in the barometer indicates that the air resting on a square foot is 70·68 lbs. lighter, it will be readily understood how a sudden fall of the barometer may indicate a relief of the pressure, which has prevented the inflammable gases in the coal from emerging, and which, removed, allows them to pour into the mine.

The relation of changes of atmospheric conditions to colliery explosions have been carefully studied by Messrs. Scott (Meteorological Office) and Galloway (Inspector of Mines), with the result that 48 per cent. of the accidents might be attributed to changes of barometric pressure, the explosions generally taking place during the first fall after a long calm, and seldom until two or three days after the minimum has been reached. 23 per cent. were attributed by them to the temperature of the atmosphere, the first hot days of spring being especially marked by accidents. When the outside temperature rises, so as to equal that underground, all natural ventilation ceases, and if the mechanical means provided have not a wide margin, an explosion results.

A high surface temperature, by reducing the quantity of air passing through the workings, allows the accumulation of gas on sensitive points; while a very low surface temperature, by drying the coal dust in the mine, tends to make a mixture which is an exceedingly explosive vehicle, even when only one-seventh of the quantity of fire-damp is present, which is ordinarily explosive with air. That this is often a cause of accident, there

can be little doubt, and it becomes an important matter for consideration, whether a system of watering dry pits ought not to be adopted. On the other hand, many explosions take place in *damp* pits, as the Queen Pit, at Wigan.

Few accidents probably occur from the use of gunpowder properly applied, no flame resulting from a shot which takes effect; but when the tamping is defective, from bad workmanship, or from a very hard rock, the shot is blown out like the bullet from a gun, fire-damp dislodged by the vibration or fall of roof may be directly ignited by the flame of powder gas issuing from the hole, or it may be driven by the sound wave through the meshes of a distant safety lamp: to the latter cause, which has been carefully investigated by Mr. Galloway, the firing of the larger number of explosions is doubtless due. But the Haydock accident proves that if ever the use of powder were discontinued altogether, this class of accident would still continue; for here the gas was ignited by the men simply by running against the stream of gas-laden air. Many days after the explosion, Evans and Clare's place, six or seven yards from the Downall Green Fault, still received so large an amount of gas that, on turning the ventilation away from it, it filled with explosive gas in four minutes, or 1,250 cubic feet of gas a minute, and lamps fired on the spot, when 13,600 feet of air played on it.

In the opinion of the Government Inspector, this explosion was not due to the "blower" of gas, but to fire-damp issuing from the adjoining old workings, the edge of which was swept by the ventilation, and which it visited first, travelling in all 300 yards from the bottom of the downcast shaft to the bottom of the upcast, supplying 200 men, and 11 horses, the amount being 28,000 feet; but this quantity is equivalent to a much larger amount in a colliery in which gunpowder is used, which was not the case in the Wood Pit.

By the Coal Mines Act, the inspection of every mine in which gas has been seen within twelve months has to be carried out every twenty-four hours, before the men enter, when one shift are working, and every twelve hours when there are two. All workmen are to be withdrawn when noxious gases prevail, and the place inspected. No lights but locked safety lamps are to be used in places where gas is likely to accumulate. Gunpowder is not allowed to come into a mine in more than 4-pound canisters, nor more than one canister to be in one place at a time. Iron or steel is not allowed to be used for charging holes for blasting.

When gas has been present during the past three months, cartridges are alone allowed to be taken into the mine, and may only be fixed by the proper official, and if a blue cap appear on

the flame of the safety lamp, cartridges may only be used in stone drifts, shafts, and places where the return air does not go into any working places, or when no persons are in the mine.

By the special rules, if a shot misses fire the place may not be examined until the lapse of an hour; and if, notwithstanding adequate ventilation, the issue of gas from the strata is such as even to show to the lamp, not actually fire, no shot may be fired until the ordinary staff is withdrawn from the pit. Further than these rules—unless the use of powder and other explosive or inflammable substances be altogether prohibited—it appears impossible to go.

The 46th clause of the Mines Regulation Act, 1872, prohibiting the use of gunpowder in dangerous seams, has recently been supported in an arbitration, conducted by Messrs. Higson and Wood, restraining the East Hetton Coal Company from using powder in working the Harvey seam on the long wall principle.

In North Staffordshire and Shropshire, Mr. Wynne reports that the use of powder in blasting is the fruitful source of explosions of fire-damp; that it shakes the roof and renders it dangerous, and, used indiscriminately, tends to the production of small coal, and the subsequent breaking-up during railway carriage of the large.

In Yorkshire, Mr. Wardell reports that the Barnsley and Silkstone seams should be worked with the safety lamp and without powder.

In Durham, Mr. Bell reports that mechanical ventilation has completely demonstrated its superiority to the old furnace; and Mr. Wales reports that nearly all the large collieries in his district have large fans at work.

The use of gunpowder in working pillars ought to be discouraged, as gas lodges in cavities in the roof, which it is impossible for a "competent person" to examine, falls of the roof constantly occur, and block up the air ways. After a fatal accident of this nature in 1876 in the 7-feet coal at the Moss Pit Main, Wigan, the use of powder was replaced with good effect by wedges, invented by Messrs. Dingley and Ackers.

A fatal accident occurred in the same year, while taking out pillars at the Westminster Colliery near Wrexham, through fire-damp issuing from an old goaf, igniting at the *candles* used by the men! Naked lights are commonly used in a large number of collieries in North Wales; and the district also has the unenviable distinction, according to Mr. Hall, of the largest number of roof accidents of any in Great Britain. In Scotland, in the western district, half the accidents of 1876 were due to this cause. In some districts, timbering is done by the men; in others, as in Durham, by the officials; but even there the

Inspector, Mr. Bell, reports that great carelessness is displayed by the men in neglecting to examine and prop their places in the absence of the deputy, or other officer; but that it has been elicited at inquests that the time allowed the collier is not sufficient for him to do his work and attend to his own safety.

In the opinion of Mr. Dickenson, the Senior Inspector of Mines under the Home Office, "*attention to safety has now been brought almost to an extreme point.* To carry it further would be impossible without making life miserable." Colliery accidents of all classes have been steadily decreasing during the last quarter of a century.

Though occasionally accidents may arise from ignorance or evasion of the law on the part of some of the staff, there can be little doubt that the large majority of explosions are due to several conditions happening at one moment, which, with our present appliances, no foresight exercised or discipline enforced on the part of the management, can possibly provide against. Just as some of the most terrible railway disasters occur to railway companies who spare no expense in providing the best rolling stock, the best steel rails, the latest signals, the most experienced staff, through an unfortunate combination of circumstances, so with the best managed mines, receiving a perfect and ample amount of ventilation, a sudden outburst of gas, from a fall in the barometer, rise in temperature, and some local unavoidable accident in the mine, which would be unimportant at any other time, brings about the fatal combination, and a catastrophe results.

No better example of this can be given than the explosion on Oct. 11, 1877, in the Wigan 9-feet coal at Pemberton, belonging to Messrs. Blundell, in which not only were 33 men killed by the accident, but my able and unfortunate friend Mr. Watkin, with two of his managers, was killed by the after-damp, in their heroic attempt to save life.

The pits are 640 yards deep, and are sunk to the Wigan seams, the King and Cannel coals, the Orrel coals, the lowest of which is the well-known Arley mine, the lowest but most valued of the Lancashire coal seams belonging to the Middle Coal Measures. The downcast or Queen Pit is 17 feet diameter, the upcast or King Pit 19 feet 4 inches at the top, and 18 feet at the bottom; the sides are lined with firebricks, and on each side are a pair of railway metals in which run the cages, six in number, and made of steel, with the steadiness and precision of an hotel lift. The two shafts are connected underground, and the ventilation effected by a Guibal fan, 46 feet in diameter, and 15 feet in width, driven by two engines, either of which is equal to the work on an emergency, no less than 225,000 cubic feet of air per minute being set in motion. The air enters

the fan through a culvert, at the top of which there is a large escape chimney with 4 large doors to allow the air to escape, should there be a blast, without injury to the fan.

The accident was doubtless due to a blown-out shot, the effects of which have been known to travel 300 yards, and to blow down a door 80 yards distant. And though a fireman may carefully try for gas at the firing point, and it may not show in his lamp, when only one or two degrees below firing point, the dislodgment by the shot may add that small additional amount of gas requisite to make it explosive. In cases of this sort, it appears well-nigh impossible to guard against explosion so long as powder is used, in any inflammable coals. At Low Hall in Lancashire, the danger is reduced to a minimum by firing all the shots at night, which is adopted by Messrs. Cross Tetly's in the Wigan 9-feet; at Park Lane this coal is worked without powder; at the Queen Pit, Pemberton, and at the Moss Pit it is not worked at all since the accidents at the respective places.*

Gas is steadily and continually being given off by fiery coals, and the more perfect the ventilation, and the less it be interfered with, the more easily is it swept away; at night when the ordinary operations are not going on, and doors being opened and shut, tubs ascending and descending, the ventilation is much more undisturbed, and the danger resulting from firing shots much reduced. At night also few lamps are in the pit, and the danger of the flame being forced through the lamp by the sound wave is much reduced. Great danger results from the employment of inexperienced persons, attracted, by the higher wages to be earned underground, from the plough and the spade, who are utterly ignorant of the use of the Davy lamp, and each one of whom is a source of danger to his fellow workmen.

The Blantyre colliery is 15 miles from Glasgow, and consists of three shafts, No. 2 being rectangular 16 feet by 8, and 130 fathoms deep; No. 3, 24 feet by 8, and 155 fathoms deep, and an upcast circular shaft 10 feet diameter, and 127 fathoms in depth. Though the mine has only been opened four or five years, 24 statute acres have been opened out, by cutting levels up the dip of the coal, or down the dip, as suited the convenience of working best, and leaving pillars 22 yards square, which system is called in Scotland "stoop and room," the stoops being the pillars. It will readily be understood that the difficulties of properly ventilating such miles of passage must be very great if not insuperable. Mr. Pickard, the agent of the Miners' National Associa-

* Five coal-seams were ventilated from these pits, the Wigan 4-feet mine taking 48,700 cubic feet of air; the 9-feet, 15,200; the King coal and cannel, 50,580; the Orrel 4-feet, 34,360; the Orrel 5-feet at Arley Main, 43,630.

tion, who assisted in the recovery of the dead after the explosion, reports that out of the 26,000 feet of air supplied to the pit, 16,000 travelled in the south part of the mine, and by the time it had reached its destination had probably lost not less than 6,000 to 8,000 feet, having to supply air through 756 yards of wood brattice and 17 stoppings.

The men who worked in the colliery at the time of the explosion used naked oil lamps fixed in their caps, in a mine in which seven days after the occurrence which destroyed more than 200 men, no less than 60 yards of level was filled with gas. Shots had been fired by the men, in the firemen's absence, and the traces removed with clay and sandpaper, and only a dozen Davy lamps were on the premises.

The explosion at Haydock on June 7 of this year took place in the Wood Pit, which has two shafts, 78 yards apart and 243 yards deep, and both are on the north side of the Red Rock Fault. The Higher Florida coal at 105 yards, and the Lower Florida at 118, are worked out. At 217 yards is the Ravenhead Higher Delf partially worked, from which a tunnel was driven through the fault, to the Higher Florida, which is thrown down 170 yards.

The workings of the Higher Florida Mine south are bounded on two sides by faults, which are known in the district as the Downall Green, north-south fault, and the Red Rock, east-west fault, which meet in the highest point in the mine, near which was the spot where Evans and Clare worked, the men in whose place the gas was.

Gas also appears to have been evolved from the old workings near the Downall Green fault.

The ventilation came through the tunnel above mentioned, and after passing through the workings made its way through a special air course, to the North Ravenhead Main Delf workings, and thence back again into the upcast shaft, the whole length of the air being 400 or 500 yards. Two furnaces in the upcast shaft at different heights provide motive power. No fans or steam jets were used till after the accident.

On the south side of the fault, the High Florida is 279 yards from the surface, 4 feet 6 inches thick, and a soft and freely worked coal not requiring blasting; no powder was used in the seam at all, and the Davy lamps belonged to the firm, and were kept riveted, and metal-sealed with their initials.

To expect that an ordinary gang of pitmen shall have a knowledge of the physical laws on which their safety depends, is for the present an impossibility, for large numbers of these men can neither read nor write; but there ought to be no difficulty in teaching them the provisions of the Act of Parliament, which they as well as the management are by law obliged to

obey,* and it would probably be found that accidents would considerably decrease if no man was allowed down a pit, until he could pass a *vivâ voce* examination in the provisions of the Act, and the management of the Davy lamp. Instruction of this sort should be given by the management at the surface, and followed up under ground; and the new men should be taught the indications by which old colliers can detect the presence of gas, by its action on their eyes and nostrils before it shows in the lamp.

How entirely the collier trusts his safety to others, is shown by the 30th general rule, allowing him to appoint two of his number to inspect every part of the mine once a month, being practically a dead letter, with the one exception, that owners provide annually a report book for this purpose, which is never used.

Apart from personal anxiety for the safety of his men, no one can doubt that every coal owner and manager is only too willing to carry out every improvement, and induce every man to guard against explosions, when he realizes the terrible struggle and almost superhuman efforts that are necessary to clean and renovate a colliery that has been wrecked and destroyed by such an accident, entailing a cost, which with the small margin of profit

* The following table, drawn up by Mr. Dickenson, shows the good results which have followed the inspection of mines—and that, notwithstanding the sad casualties in Great Britain in 1877, it was twice as favourable as the early years of inspection:—

	Total accidents	Persons employed	Employed to each accident	Deaths	Employed to each death
1851	698	216,217	310	984	219
10 years ending 1868 . .	7,739	2,460,322	318	10,018	245
10 years ending 1870 . .	8,228	3,192,405	388	10,626	300
1871	826	370,881	448	1,075	345
1872	894	418,088	468	1,060	374
1873	973	512,199	526	1,069	479
1874	895	538,829	602	1,056	510
1875	927	535,845	578	1,244	430
1876	839	514,532	613	933	551
1877	864	494,386	572	1,208	409

The deaths in 1877 being more in proportion than in 1876, it is of interest to examine to what they are due; and taking Mr. Dickenson's own district, North and East Lancashire, as a representative area, it is somewhat startling to find that, out of 9 fatal explosions of fire-damp causing 42 deaths, 6 of these accidents occurred in places where naked lights are used: in several of these accidents blown-out shots sucked out the gas in the coal.

now earned in the coal trade, means ruin to the small proprietor, and no interest on capital to the large.

That no further compulsory power can be added by legislation to the powers already existing, provided they were carried out, appears to be a fact; but unfortunately this, with the present staff of inspectors, is not possible, for though the senior officer tells us he travelled no less than 15,695 miles last year, and was occupied 318 days in the execution of his duties, the districts given to those gentlemen are so vast, that Mr. Hall, in his evidence on the Haydock Explosion, which occurred in his district, tells us, he cannot pay his routine visit to any colliery under an interval of six years.

ON THE RADIOLARIA AS AN ORDER OF THE PROTOZOA.

By Surgeon-Major G. C. WALLICH, M.D., &c.

Continued from page 281.

It is in the second order of the Rhizopods, namely, that which comprises the *Plagiacanthidæ*, *Acanthometræ*, *Thalassicollidæ*,* and *Dictyochidæ*, that the first trace of structural advance is made manifest by the presence of a distinct membranous or "capsular" covering to the nucleus. The more deeply tinted masses, of which mention was made just now in the *Foraminifera*, though not true nuclei, owe their denser appearance to the accumulation of the minute sarcodic granules, which are more or less uniformly diffused in the more limpid and colourless portion, whilst the creatures are in their natural state. But there is every reason for believing that these granules are of the same nature, and contribute to the reproductive process in nearly the same way as the granules contained within the membranous capsule, and those present in the sarcode mass exteriorly to it, of the superior Order. But in this case the evolution of a true *tissue* undoubtedly indicates physiological advance, and hence becomes a safe Ordinal distinction.

In those Rhizopods which are endowed with membranous capsules, it seems probable that nuclear granules and even sarcoblasts are able, by some means or other, to force a way through

* If Hertwig's observations on the *Collosphæridæ* and *Sphærozoidæ* are as accurate as they appear to have been carefully made, it is evident that the whole of these remarkable composite forms, of course including the single exceptional genus *Thalassicolla*, ought to be removed from amongst the Rhizopods and placed—at all events provisionally—with the *Heliozoa* (assuming that these multiply also by *zoospores*, furnished with flagella, whether single or double), as a distinct group between the Rhizopods and the *Gregarinidæ*; inasmuch as neither the difference of habitat, nor the mere difference in colour of the sarcoblasts of the two families can be held to be a cause for their being kept distinct.

the capsular wall into the peripheral stratum of sarcode. In *Sphærozoum* and other members of the *Thalassicollidæ*, the transit of these bodies from within the capsular chamber to the space between it and the perforated siliceous shell appears almost certain, although I am not aware that the occurrence of a sarcoblast actually in course of transit through the capsule has as yet been noticed. But although it would obviously be premature to deny that any permanent apertures exist in it simply because they defy our vision, I am strongly inclined to suspect that they do emerge, and that the orifices are immediately sealed up again, since no mere osmotic action could possibly account for the phenomena. But until the existence of permanent apertures, or the actual transit of the sarcoblasts, despite the absence of such, shall have been seen, the whole question must, of course, remain an open one.

But to return to the arguments based upon the *presence* of the capsule. It is admitted by the supporters of "multiple cell-formation amongst the *Radiolaria*" (I presume only amongst the composite forms), that reproduction may take place: firstly, "by spontaneous fission or giving off a single or a few capsules, these modes of increase having, however, not been actually observed, though it is certain that single capsules (however derived, whether from spores or from segmentation) do exist separately. The colonies may also be increased by juxtaposition, and the mass of an existing colony by the rapid fission of its component capsules, the process taking place centrifugally in the shelled and irregularly in the shelless (*sic*) forms. Secondly, with regard to the capsules themselves, it is certain that they may increase by spontaneous fission into two, three, or more secondary capsules, and that this process may repeat itself indefinitely. Thirdly, with regard to reproduction by spores,* it is certain that such a process occurs in *Acanthometra*, *Thalassicolla*, *Sphærozoum*, *Collosphæra*, and *Collozoum*, AND MOST PROBABLY IN ALL THE RADIOLARIANS. The spores are formed by the breaking up of the contents of the central capsule into small particles, which become directly transformed into spores, each spore containing a nucleus and *fat*-granules, and also a crystalline body, when such bodies are found within the capsules in which such spores arise. Each spore is provided with a *flagellum*, and it is doubtful whether more than one *flagellum* ever exists to one spore." (Memoir, p. 167.)

* It will be seen that here, as elsewhere, in Mr. Mivart's observations, the terms "zoospores" and "spores" are both employed in describing the reproductive process in the *Radiolaria*. This must necessarily lead to great confusion, even were it possible, which it is not, to admit spore-formation in a single family of the true Rhizopods.

After saying that the contents of the capsule may break up into variously shaped masses, of various sizes, and that these again subdivide into zoospores, we are told that "these different sets of masses give rise to two kinds of spores, one set producing *microspores*, the other *macrospores*, bodies having *different but as yet unknown* functions; but that beyond these different stages no observations have as yet gone, *the transition from the zoospore to the capsule remaining unknown.* The zoospores, however, have no enveloping membrane, and the young central *capsules* are in like case.* If the capsules proceed from the former, the *Radiolaria* so far resemble the *Heliozoa*; and if the processes observed by Müller, as existing in the young enclosed *Acanthometræ*, resembled the processes of such organisms as *Actinosphærium*, we should have another approximation between these two groups." (Memoir, p. 168.)

In submitting these lengthy extracts I feel, nevertheless, that no apology is demanded of me, inasmuch as it can only be by perusing them that the inherent and amazing unsoundness of the Radiolarian arrangement is to be adequately estimated. As already stated, it is impossible within my present limits to discuss in detail the various points connected with the reproduction of the composite group—the *Thalamophora* as they are now designated. We have seen how very freely such expressions as *spores*, *zoospores*, *microspores*, *macrospores*, *flagella*, *spontaneous fission* of the *contents* of the *capsule* into any number of secondary *capsules*, *fat-granules*, *livers*, *cilia*, *parasites*, *alveoli*, and "*young capsules which have* NO *enveloping membrane*," have been made use of in describing the characters said to distinguish "the group of the *lowest animal forms called Radiolaria.*' I simply put it to those who are practically conversant with the Rhizopods as a whole to say whether any organism whatever described as possessing characters such as those referred to ought for a moment longer to be retained in any classification of these organisms. As for telling us that "IF the processes observed in the young *Acanthometræ* resembled the processes of such organisms as *Actinospherium*, this would be another reason for approximating the *Heliozoa* and *Acanthometræ;*" it would, I submit, be just as pertinent were we to say that IF the *Acanthometræ* or any other group or family whatever of the Rhizopods (with exception of the avowedly aberrant *Thalassicollidæ* and *Sphærozoidæ*), propagated by zoospores, microspores, macrospores, and so forth, there would be reason for approximating *them* to the *Heliozoa.* It is these "*ifs*" which, in an elaborately written essay, make all

* There surely is some "clerical error" here!

the difference between fact and mere guesswork, and are therefore singularly out of place.

But despite all drawbacks, in attempting to advance the *Composite Thalassicollidæ* into the front rank of the "Radiolaria," Mr. Mivart has rendered us a signal service by so directing attention to them that it has become absolutely indispensable that the Radiolarian classification should be revised, and the proper location for the *Thalassicollidæ* determined. Whilst this is being effected it would be well to ascertain whether the *Noctilucæ* might not with propriety be referred to the same group. It is true that nothing is as yet known of the reproductive process of these remarkable and common organisms. But, after all, knowing too little is better than knowing too much. Time and patience usually suffice for the discovery of missing links; but neither time nor patience is profitably expended in proving negatives.

As for the "streaming of granules" and the occurrence of *pseudo*-pseudopodia imbedded within the extra-capsular sarcode of some of the *Thalassicollidæ*, both phenomena are present also in *Noctiluca*. And, to say the least of it, inasmuch as not a single example is producible of *endogenously* projected and active pseudopodia occurring *within* the body substance of any true Rhizopod, we have in this distinction a character which furnishes the very antithesis of an "approximative" bond between the former organisms and the latter.

Mr. Mivart alludes to the discovery by Haeckel, since his "*Die Radiolarien*" appeared, of the remarkable "*Myxotrachia*," which Haeckel associates with his "*Polycyttaria*," or compound *Radiolaria*. Not having seen this creature, I can form no definite ideas as to its relations. But I do not hesitate to affirm that, if the figure given of it is accurately drawn, although it may be a Radiolarian in Sir Wyville Thomson's sense, it is unquestionably not a Rhizopod, and that nothing could more forcibly demonstrate the purely arbitrary character of this classification than the admission of so palpably distinct a form, even allowing the fullest scope to Mr. Mivart's reservation that it is "a curious and exceptional form."

Before passing on to the concluding section of this article, I may be permitted to say that it is highly gratifying to find from Mr. Mivart's memoir that "*Hertwig* has strongly insisted (as I did fifteen years ago) upon the greater importance of A *Nuclear Vesicle* as a classificatory character than any characters which can be derived from the skeleton"; (Memoir, p. 173), and that Mr. Mivart "quite agrees that it forms a most important distinction, which he therefore proposes to adopt provisionally, fully bearing in mind that it may hereafter be very widely, if not all but universally, present in the group," adding

that he "*would anyhow make its presence or absence a* PRIMARY *character*, and therefore follow Hertwig in separating from Haeckel's '*Collida*' those forms which have the nuclear vesicle, and uniting them with the other genera which possess that structure into a group *Vesiculata*." (Memoir, pp. 173, 174.)

After a prolonged effort to satisfy myself as to what Mr. Mivart may mean when using the term "*a nuclear vesicle*," declared by him to constitute a most important distinction, &c., I am constrained to admit that I have given up the task in despair. Of course it may be that this is another of the convertible terms he so frequently employs, and is identical with the "porous membrane called the capsule," of which we have heard so much, which would in that case explain why the term *nuclear vesicle* was so carefully eschewed in the first thirty-six pages of his Memoir, inasmuch as it would have been an avowal of the *non-existence* of the declared typical character in the most important, widely distributed both in the recent and fossil state, and most typical (according to the accepted estimate) of the Radiolarian families, the *Polycystina*, of which I have been the persistent advocate. But then Mr. Mivart would have had to cancel one of the most important of the structural characters which he ascribes to six out of the seven great "sections" into which he now condenses the fifteen groups of Haeckel, and which he embodies always in the three words, "No nuclear vesicle."

If, however, he employs the term to signify the presence of a *vesicular nucleolus*, within the true nucleus of such forms as the *Acanthometræ*, &c., he certainly appears to me to be assuming the presence of a structure in the Rhizopods, which does not, under any circumstances, enter into any portion of their organization.

From one short passage in Mr. Mivart's Memoir, this would, however, seem to be his meaning. For, after referring (at p. 141) to the intra-capsular sarcode of *Thalassicolla*, *Thalassolampe*, and *Physematium*, which genera alone contain "Alveoli," he goes on to say that it also "constantly contains one or both of two sets of structures, which structures, according to Hertwig, bear to the whole capsule the relation of *many simple nuclei or of a single complex nucleus to a cell*;" and further, (p. 142,) that "the complex nucleus is a *small vesicle*, the *Binnenbläschen* or *vesicula intima* of authors, formed of *porous* membrane similar to, but more delicate than the capsule itself." But even here a new element of confusion is introduced by the statement (at p. 162) that "Hertwig considers the capsule of *Collozoum* to be a multinucleate cell or *syncytium*, and agrees with Schneider in thinking *that it answers to that part of the sarcode of the Foraminifer which lies within the*

shell. He considers, therefore, that 'IT IS NOT AN ORGAN,' and certainly not 'A GENERATIVE ORGAN!'"

I shall now proceed to bring these lengthy, though I trust not altogether fruitless observations of mine to a close, by sketching as a supplement to my arrangement of the Rhizopods generally, the classification and characters by means of which the principal subdivisions of the POLYCYSTINA, and every individual comprised within them, may, with a little care, be recognized and identified at any stage of their history, whether in their recent or their fossil condition. (See pp. 374, 375.)

Order I. HERPNEMATA.—The primary and secondary characters of this order are as follows:—No definite nucleus. No contractile vesicle. Sarcode without any permanent differentiation into endosarc and ectosarc, but consisting of purely homogeneous, almost colourless, glairy basal SARCODE, within which granular particles, representing "*formed material*," of more consolidated texture than the basal sarcode, and of which the *sarcoblasts* or yellow reproductive bodies, constituting in the *Herpnemata*, the sole representatives of the *nucleus* which is present in the two higher orders, are mainly built up. Pseudopodia numerous, more or less irregular, and forming frequent anastomoses, and exhibiting when projected the characteristic phenomena of pseudo-cyclosis. Both in the *Foraminifera* and *Polycystina*, when in an active living condition, the exterior of the shells is invariably enveloped by a delicate film of the basal sarcode. Shell or test, in the *Foraminifera*, either calcareous and deposited in a crystalline state; or having a calcareous basis into which are impacted mineral particles selected from without by the animal. In the *Polycystina*, the mineral portion, which may rather be regarded as an internal framework or skeleton than a true shell, is invariably siliceous, and throughout formed into one continuous piece. (See Explanation of Plate VI., Figs. 1, 2, 3 & 5.)

Order II. PROTODERMATA.—Definite nucleus present; nuclear mass presenting a nucleolus, and enveloped in *a distinct and firm membranous capsule*. Sarcode somewhat more differentiated in appearance, but only in so far as the granular particles are, generally speaking, more closely confined to the central region. Pseudopodia never so numerous as in the *Herpnemata*; more rigid and tapering, and only rarely sending off branches from one to the other. Reproduction by sarcoblasts; * which are to be seen in the general mass of the body-substance, and, occasionally, within the nuclear capsule. These are, as in the *Herpnemata*, of a yellow colour.

In the *Plagiacanthidæ* or first family of the *Protodermata*, the name of which I take from the *Plagiacantha arachnoides*

* From σάρξ, flesh, and βλάστη, a growth or bud.

RHIZOPODA.

No definite nucleus *No* contractile vesicle.	Definite nucleus. *No* contractile vesicle.	Definite nucleus. Contractile vesicle.
1.	2.	3.
HERPNEMATA.*	PROTODERMATA†.	PROTEINA‡.
Shell never siliceous.	Skeleton solid.	Pseudopodia monomorphous.
FORAMINIFERA.	PLAGIACANTHIDÆ.	ACTINOPHRYNA.
§ *Lieberkuhnia* (Clap.).	ACANTHOMETRINA.	*Actinophrys*
Pamphagus ? (Bailey).	THALASSICOLLINA ?	*Gromia.*
Skeleton invariably siliceous.	Skeleton tubular.	*Lagynis.*
POLYCYSTINA.	DICTYOCHIDÆ.	*Euglypha.*
	SPONGIDÆ.	*Cadium* (Bail.)
		Protocystis (Wal.)
		Plagiophrys ? (Clap.)
		Pseudopodia polymorphous.
		AMŒBINA.
		Amœba.
		Difflugia.
		Arcella.
		Pseudochlamys.
		INFUSORIA.

* From ἕρπω, to creep, and νῆμα, a thread.

† From πρῶτος, first or earliest, and δέρμα, skin.

‡ This name is adopted from the classification of MM. Claparède and Lachmann, inasmuch as the order so designated comprises the two families whose affinities they recognized, although on grounds which appear to me of very minor importance as compared with those now adduced.

§ See explanation of the Plate accompanying this paper, Fig. 1, and Deep Sea Researches on the Biology of *Globigerina* (already referred to at p. 270 ante); at p. 54 of which the following passage occurs:—"I may state that every fresh observation seems to lead to the conclusion that, so far from its being probable that the further extension of our knowledge of the lower forms will bring to light beings consisting absolutely of homogeneous protoplasm, more close and careful scrutiny will eventually show that *all* either have a definite nucleus or diffused nuclear masses, identical with the Sarcoblasts of the *Foraminifera*, *Polycystina*, *Acanthometræ*, &c., and with those of the *Amœbæ*," &c.

POLYCYSTINA.

Animal presenting the distinctive characters of the Herpnemata. Skeleton invariably and purely siliceous, of crystalline clearness, colourless, never tubular in any portion; continuous, so as always to form one piece only, no matter how far growth has proceeded; generally foraminated, although the apertures vary greatly in size, and the solid parts also vary from being comparatively stout to being mere threads, or a network of threads, as on the spongy forms. The interior of the skeleton more or less imperfectly divided into chambers.

DIVISION 1.
(*a.*) Omphalostype symmetrical.
Omphalic chamber spherical.

DIVISION 2.
Omphalostype not symmetrical.
Omphalic chamber not symmetrical, generally more or less pyramidal.

CYCLODINA.

1.

(*b.*) SPHÆRODINA.
Successive chambers, when more than one, arranged concentrically around the omphalic chamber, and developed upon and around the *Acanthostypes* (*f*) which originate from the omphalostype. Typical Genus, *Haliomma* (Ehr.).

2.

(*c.*) DICHODINA.
Successive chambers more or less compressed, discoidal, or lenticular, but interrupted at opposite poles. Typical Genus *Amphidiscus* (Müller).

MONODINA.

(*d.*) ACTINODINA.
Successive chambers compressed, discoidal, or lenticular, concentrically arranged in a plane at right angles to the short axis, with symmetrically placed radiating lobes, varying in number from two to six, or even more, the concentric arrangement of the minute siliceous fibres being often continued into such rays. Typical Genus, *Astromma* (Ehr.).

(*e.*) MONODINA.
Successive chambers arranged generally one in front of the other, in linear series; although, owing to accidental malformation the axis of the chambers may, to this extent, not maintain a direct line. Typical Genus, *Podocyrtis* (Ehr.).

a. From ὀμφαλός, the navel, and στύπος, a stem.
b. From σφαῖρα, a sphere, and ὁδός, a way or method.
c. From δίχα, in two, apart, and ὁδός, a way or method.
d. From ἀκτίν, a ray, and ὁδός, a way or method.
e. From μόνος, single, one, and ὁδός, a way or method.
f. From ἀκανθά, a spine, and στύπος, a stem.

of M. Claparède ("Monatsb." 1856, p. 500) and which is generally identical in all its characters with the *Acanthodesmia*, of Johannes Müller (1858), we have the connecting link between the siliceous structure in this Order and some of the numerous aberrant varieties of the siliceous framework of the *Polycystina*. In this family the shell is very rarely symmetrical in any of its aspects, being formed (as seen in Fig. 6) of three or more straight or branching, and sometimes very *bizarre*-looking siliceous rods or bars, united together at one or more points, so as to form a solid piece. Within the rude cavity thus formed, the bulk of the sarcode body is sustained, a delicate investing layer being, however, as in the former case, extended exteriorly over the framework. Nucleus and sarcoblasts as described in the general characters of the order. To this family will be found to belong those strikingly curious forms in which the tendency to unsymmetrical growth attains the greatest limit, and which are known under the names of *Dictyospyris*, *Stephanolithis*, *Cladococcus*, *Stylocyclia*, and *Acanthodesmia*.

In the *Acanthometrina* there exists a much more complex, generally perfectly symmetrical, and beautiful arrangement of the siliceous skeleton, which in all the true *Acanthometræ* consists of a varying number of radiating spicules, disposed in pairs, and uniting at the central axis of the structure merely by close juxtaposition of their conical-shaped bases. Occasionally the spines are blade or oar-like—occasionally furnished with hilt-like processes placed at some little distance from their axial point of union; and when these processes so far extend themselves as to coalesce with those of the spicules next to them, they form perforated chambers often resembling those of some of the Polycystine *Haliommata*. The nuclear mass is, in the *Acanthometræ*, not enclosed within a mere membranous chamber, but around the point of junction of the spines, which it accordingly more or less completely embraces and conceals. In the very early stage of *Acanthometræ*, the development of the spines takes place at the central point of the sarcoblast, and the spines as they grow gradually push the investing nuclear capsule (which is also developed in a very distinct form at this early period of the organism's history), before them, just as the finger may push before it a glove-like process of thin india-rubber. In all probability the spines, after a certain time, cause the rupture of the nuclear capsule, which causes it to hang from their extremities in curtain-like festoons. It is extremely tough, however, and so hyaline that the structure within, until the nuclear mass is reached, is plainly visible. The sarcoblasts are, apparently, not quite so numerous in the *Acanthometræ* as in the *Foraminifera* and *Polycystina*. But in all other respects they are identical.

It is the prevalent opinion, originated by Müller, and adopted by all later writers without exception, that the spines of the *Acanthometræ* are *tubular*, and that processes of the sarcode pass through the tubules and show themselves at their apices in the shape of pseudopodia. This, I have long since tried to show, is altogether an error, resulting from the high refractive quality and the *imperfectly* siliceous nature of the material of which they are composed in this family alone of the *Protodermata*, and in one or two curious free-floating Polycystina; the illusory appearance of tubularity being caused by the longitudinal ribs or flanges which are present in most spines, and when looked at, under the microscope, on one or other of the faces upon which they naturally take up their position, give the appearance of the spines being hollow. Just in like manner in certain genera the spines are apparently truncate and cleft in half at their extremities by a deep angular notch like the letter V. But so far from this being, as alleged by Müller and others, a cleft, the V is formed by the rectangular spines having a small portion of their ends cut off from opposite *angles* in such wise that a "knife-edge" is produced diagonally from corner to corner; the intensely hyaline nature of the material preventing the *knife-edge* being seen, except under the best illumination and under the use of very high magnifying power.

I may remark also that it was long ago pointed out by me that the reason why the spines of the *Acanthometræ*, which abound in the surface waters of the ocean, are never found in the deep sea deposits, is that owing to this imperfectly siliceous character, they become dissolved before they reach the bottom. This opinion has also been very recently adopted by Sir Wyville Thomson. (See Figs. 7, 8, 26, 26 *a*, 26 *b* and 27.)

Of the *Thalassicollidæ*, it is unnecessary for me to give any further description here than I have already given in the body of my paper; inasmuch as they are, under any circumstances, a very aberrant group; and any attempt to picture their characters is calculated, in my opinion, rather to increase than diminish the difficulties which surround the history of these lower forms of animal life.

The *Dictyochidæ* are also an aberrant family, to this extent, that their siliceous framework is invariably, and in every part, tubular. It consists also invariably of two perfectly distinct but symmetrical and equal-sized basket-like portions, within the cavities of which the bulk of the body-substance is contained, and by it protected. A *Dictyocha* may therefore be regarded as a symmetrically formed *Plagiacantha* or *Acanthodesmia*; with this difference, that the framework of each individual is tubular, like a sponge spicule, and always composed of two symmetrical and equal pieces, instead of one unsymmetrical one.

As the *Dictyochidæ* have often been met with by me in tropical seas, grouped together in numbers in a common sarcodic matrix, and they possess the characteristic tubularity of which I have spoken, it appears to me that they form the only true connecting link between the Rhizopods and the Sponges.

It has already been shown by me why I hold that the *Polycystina*—which have of late years been seized upon to help to build up the motley group called *Radiolaria*, are disqualified through the absence of an *encapsuled* and *definite* nucleus, from being placed in any other position amongst the Rhizopods, than with the *Foraminifera*. It is, however, only because they have been classified in like manner with the other groups arranged under the term *Radiolaria*, without any further result, so far as I can see, than to increase the list of so-called genera and species, and without due weight being ascribed to their extreme varietal tendencies: that I avail myself of the present opportunity to furnish a somewhat more complete, though necessarily brief outline of their classification and characters than has heretofore been offered by me.

In the earliest observable stage of the siliceous skeleton of the *Polycystina*, two very definite and important formations take place within the sarcoblast. These, apparently, never vary so far as to render their characters uncertain at any subsequent period in the history of the organism. To these two formations (in consequence of their extreme value for determining their typical starting-points), I have given the names of *Omphalostype* and *Omphalic chamber*. The first constitutes the axis of all future development of the siliceous structure. The latter constitutes the omphalic chamber, which answers to the primordial chamber of the closely related Foraminifera. Both are secreted, one, however, after the other within the *nucleus* and peripheral portion of the sarcoblast which produces them; the omphalostype consisting in the Symmetrical or *Cyclodinal* division of the *Polycystina*, of two, or four, rarely more, intensely delicate and minute *spinelets*, united at their bases, but upon and around the free extremities of which the first little spherical chamberlet or omphalic chamber is secreted, whilst as yet the dimensions of the sarcoblast have but very slightly increased; the second and each succeeding chamber of the series being constructed on precisely the same plan; that is to say, by the continuous growth, radially outwards of the spines, and the repetition, at stated intervals, of the formation of another perforated siliceous chamber; until at last there exists a series of gradually increasing hollow spheres, retained one within the other, and *in situ*, by the spines. In the Non-symmetrical or *Monodinal* division, the omphalostype consists of extremely delicate siliceous fibres,

which at once assume the shape of a coronet, inasmuch as they present a basal ring, from the upper margin of which, generally three principal loops are projected upwards and convergingly in a graceful curve, until they meet at a central point where they terminate in a single spike, resembling that of a modern helmet. From the lateral aspects of the loops, the network forming the first or omphalic chamber characteristic of the *Monodina*, is secreted; all subsequent growth and extension of the siliceous material taking place only from the front or opening of the coronet-like framework, no matter how many chambers may be produced. As already stated both the rudimentary spinelets and the omphalic chambers of the individual, throughout the whole of the *Polycystina* (as formed whilst still within the parent sarcoblast) remain constant and determinable to the last, no matter how exuberant or even monstrous the growth may, and does very often, become. It is this *omphalic chamber*, and the chamber formed subsequently to it, which have very frequently been described by writers, who have seen them imbedded in the semi-transparent dead sarcode, as the *nucleus* and *nucleolus* of the *sarcode*.

In the concentrically formed division, we find certain plans of growth which might, under a cursory view, be regarded as exceptional; namely, in those examples in which the *mature* framework is not spherical, but compressed so as to assume a more or less discoidal, lenticular, or even stelliform shape. But even in these forms, and in forms in which we meet with an unmistakable admixture of different plans of growth, as if the organism had run riot from sheer exuberance of development which surrounds the central or normal portion by a network, or interrupts one plan of growth and alternates it with another, as if doubtful which would suit it best, the *omphalostype* and *omphalic chamber* remain to the last, and furnish us with the most conclusive evidence to be had, that in naming the numberless varietal forms which these beautiful structures constantly assume, any number of cabinet specimens may be identified, but not a single step will be gained in our knowledge of the causes which produce them.

EXPLANATION OF PLATE VI.

N.B.—These figures are all more or less diagrammatic, and meant only for the purpose of illustrating the main points in the accompanying paper.

FIG. 1. *Lieberkuhnia*, (Clap.), showing the central mass of naked sarcode, the pseudopodia being omitted for want of room. The object of this figure (which is a rough copy of Claparède's) is to show that in the original, *sarcoblasts* are distinctly visible. As they are not *yellow* in this genus, Claparède would seem to have failed in recognizing them as the representatives of his "yellow cells."

FIG. 2. A mass of sarcode in the chamber of a Foraminifer, a Globigerine shell, exhibiting sarcoblasts. 2 *a*, a detached sarcoblast seen without focussing down to an equatorial plane. 2 *b*, showing the same with the central nucleus of clear basal sarcode, as seen when the focussing is so adjusted as to show the equatorial plane.

„ 3. The chambers of a Rotaline shell filled with sarcode, and containing sarcoblasts.

„ 4. A *Haliomma* (a Polycystine) showing the nuclear sarcode aggregated around the internal chambers; and sarcoblasts between the nuclear mass and the inner wall of the outer foraminated spherical chamber.

„ 5. A broken shell of the same, showing the disposition of the omphalic chamber, and the second and third chambers; the spines; and the sarcoblasts within the sarcode.

„ 6. *Acanthodesmia* (Müller) showing the irregular character of the siliceous framework and the relative position of the sarcode and sarcoblasts; the nucleus being 'in the second Order' enveloped in a distinct membranous capsule.

„ 7. *Acanthometra*—illustrating the radiate arrangement, and axial point of union of the spines at their conical bases; the *nucleus* surrounding the bases of the spines for some distance, and the *nuclear capsule* (which in the early state of the organism, closely invested it) being now pushed outwards in every direction by the growth of the spines, and probably pierced by them. The sarcoblasts shown in the mass of the sarcode within.

„ 8. A young *Acanthometra*, showing the nuclear capsule already apparently pierced by the longer spines, and pushed outwards in other directions by the series of shorter spines. This is the condition which the young *Acanthometræ* usually present. The *nucleus* is not represented, being at this stage of the organism's growth scarcely visible, both from its minute dimensions and comparative absence of colour.

„ 9. A separated siliceous chamber of one of the composite *Collosphæridæ*—the perforations on which give it, at first sight, the appearance of a Polycystine shell. Within is seen the massive, often richly coloured, nucleus, its nucleolus, and its investing capsular membrane, with sarcoblasts in the sarcode between the capsule and the wall of the shell.

„ 10. The siliceous structure of *Dictyocha*, as seen from above; the *twin* siliceous framework being very faintly indicated beneath.

„ 11. Diagrammatic outline of the two basket-shaped, twin pieces, which enter into the structure of each living *Dictyocha*, the *nucleus*, *nucleolus*, *membranous capsule*, enveloping sarcode, and *sarcoblasts* being shown also.

„ 12. The *sarcoblast* of the *Polycystina*, *a*, as seen in an axial plane, in order to show the point of union at the immediate centre of the spinelets which constitute the *omphalostype* of the *Cyclodinal* division; and *b*, the appearance of the same from above.

„ 13. A sectional view of a *Haliomma*, showing a *sphærodinal omphalostype*; the *omphalic* chamber around it, two succeeding cham-

bers, and the spines. 13 *a*. The *omphalic* chamber just developed, and the projecting spines. 13 *b*. The same advancing towards the completion of a second chamber.

Fig. 14. Sectional view of one of the discoidal *Haliommata*. The *spherical omphalic* chamber shown at its centre, with spines projected from it only in one axial plane; the peripheral spines taking their rise altogether from the external surface of the shell.

„ 15. Side view of *Haliomma amphidiscus* (Müller), one of the *Dichodinal* series, showing the interrupted growth of the external chamber which is always more or less compressed. An internal chamber is seen within the outer one, and two spines extending from its long axis. Of course in this the *omphalostype* could not be represented. But if seen, it would invariably be of the perfectly spherical form characteristic of the *Cyclodinal* division.

„ 16. A *Haliomma*—showing the second chamber—within which is seen the spherical *omphalic* chamber, and the four spines. From the long axis of the shell, two of the delicate internal spines are shown suddenly increasing in massiveness. This condition is of very frequent occurrence.

„ 17, 18, 19 are various beautiful and not uncommon kinds of radiate *Astrommata* of the *Actinodinal* series, in which the growth of the structures, (owing to the almost endless number of varietal and overlapping forms they assume) appears after the formation of the omphalic chamber and the one succeeding it, to diverge from the primary plan of growth in almost any direction.

„ 20. A not uncommon Polycystine form, met with at the surface of tropical and subtropical seas, in which the shell is so imperfectly siliceous as to yield to pressure, and sometimes even to become distorted without fracture occurring. The material, however, is not at all highly refractive, as is the case with the Acanthometrine spines.

„ 21. Represents another not unfrequent Polycystine shell from the same seas, but which is perfectly siliceous. Whether these two last represented forms are as closely allied as they appear to be, cannot be determined until the animal of the imperfectly siliceous form shall have been carefully examined in a recent state.

„ 22. *Pterocanium*—one of the *Monodinal* series—a side view, showing the spike-like spine, the rudiment of which was formed at the apex of the *omphalostype*; and has since then only increased in thickness and length. The *omphalic* chamber is seen supporting it, but, of course, very greatly extended outwards in dimensions and thickness.

„ 23. The same as seen from the lower aspect. The aperture is more frequently almost as large as the diameter of the shell at this point, but occasionally, as in the specimen figured, the deposit of silex has gone on until the main opening is very little larger than the surrounding perforations in the shell.

„ 24. Gives an enlarged view of a *Monodinal Omphalostype*, such as occurs in the form depicted in the last two figures.

FIGS. 25, 26, and 27 give diagrammatic but correct transverse *sectional* views of common forms of Acanthometrine spines, in order to show the ribbed or flange-like structure which engenders the appearance of tubularity in these spines, in consequence of the rib or flange-like portion extending longitudinally along the centre of the spines.

„ 28, 28 *a*, and 28 *b* are diagrammatic representations of the truncate *Acanthometrine* spines, presenting the *split* appearance, 28 *b* showing the *split* when the object is not viewed under a sufficiently high magnifying power, in a suitable medium, or under imperfect illumination. Fig. 28 shows the same, when proper definition is secured.

EUCALYPTUS GLOBULUS

W. GRIGGS, LITH. PECKHAM.

THE EUCALYPTUS GLOBULUS.

By M. BETHAM EDWARDS.

[PLATE VIII.]

IN one of the stormiest years on record, 1792, when the French Republic was proclaimed, the unfortunate Louis XVI. arraigned before the Assembly, and all Europe armed itself against France, a momentous discovery was made by a French naturalist named Labillardière. A few years earlier, a grand scientific expedition had been started under royal auspices and the direction of the famous navigator La Pérouse; but as nothing had been heard of it since 1788, the National Assembly dispatched two ships in search of the missing vessel. Thus came about the discovery of the now famous *Eucalyptus globulus*. The fever-destroying, health-giving Australian Blue Gum Tree, or Eucalyptus, destined three generations later to transform miasmatic plains and fever-breeding marshes into healthful resorts, to alleviate moreover some of the worst ills which flesh is heir to, and further to open countless sources of wealth and industry, may be regarded as an offspring of the great French Revolution. Very probably Labillardière, with the prescience of true genius, foresaw many of the important results of his treasure-trove, but all were far beyond human sagacity to predict. Could he in spirit now transport himself from one Eucalyptus plantation to another—from Algeria to Ceylon, from the Cape of Good Hope to Spain, from New Zealand to the Riviera; could he compare the aridness and unhealthfulness which had been with the verdure and salubrity now existing, he might indeed feel a thrill of pride and gratitude for the benefits conferred by his agency upon mankind. Could he know how the ships now crossing each other on the great ocean highways transport precious bales of Eucalyptus seed to all parts of the world, destined to make far-off wildernesses blossom as the rose, he might indeed exclaim in the words of the Roman poet:—

Quæ regio in terris nostri non plena laboris!

Labillardière thus describes his discovery, made in Van Diemen's Land, on May 12, 1792: "The Eucalyptus, one of the loftiest

objects in nature, only bears flowers towards its ummit. The trunk is suitable for purposes of naval construction, and would serve for masts, though not so light and elastic as that of the pine. We were obliged to fell one of them in order to procure the flowers. The sun was then very hot, and the sap rose to the surface abundantly. This handsome tree, of the myrtle tribe, has a thin bark; the branches curl a little in shooting upwards and, have alternate leaves, slightly curved. The bark, the leaves, and the fruit are aromatic, and might be substituted for those of other trees hitherto supplied by the Molucca islands." He named the tree, then known only as the Blue Gum Tree, *Eucalyptus globulus*, *εὐκάλυπτος* (meaning, in Greek, well hidden), from the shape of the calyx; and *globulus*, (Lat., a button), from the likeness of its fruit to a coat-button.

When we consider the stately height of the Eucalyptus we need not wonder that it attracted Labillardière's attention. Specimens have been seen lofty enough to tower over Strasburg Cathedral and cast a shadow on the Pyramid of Cheops!

Visitors to Kew, perhaps, seldom pause to study the tall, slender, bluish-green trees so conspicuous in one of the glass houses, or imagine the important part they are destined to perform in the history of the world. To see them in full glory we must visit Tasmania, where these giants of the forest world surpass in height the towering Wellingtonias of California; but along the coast of the Riviera, in Spain, in South Africa, and in Algeria they cannot fail to attract the attention of travellers. In England very few experiments have been successful, though occasionally, as in gardens at Dulwich Common, are seen flourishing young trees of a year's growth already a yard in height. This is to be accounted for by the mildness of the late winter season. When planted in glass houses they spring up with such rapidity that none are lofty enough to hold them, and every year they have to be lopped, to the great detriment of their general appearance. Opinions vary much as to the beauty of the Eucalyptus. Whilst some writers enthusiastically extol it, as one of the most conspicuous ornaments of the vegetable world, others consider it as acceptable only on utilitarian grounds, and having no claim whatever to comeliness, much less grace. A mean is to be drawn between these two views, the Eucalyptus having certainly outward attractions, though in far inferior degree to the elm, the oak, and the birch. The flowers of some species are particularly lovely and the seed-vessel very curious.

Madame Bodichon, writing in the *Pall Mall Gazette*, thus describes a young Algerian-Australian Eucalyptus forest visited in 1874: "On M. Trottier's estate at Hussein Dey we walked under tall trees on an average fifty feet high, which, seven years ago, were planted with seeds not so big as a mustard-seed. This

particular plantation was on bad soil, and had not received any experienced care, yet the growth of the trees was truly marvellous. In this evergreen wood all round us were tall, reddish, smooth stems, with the bark hanging down in a ragged, untidy manner —for the tree sheds its bark in winter—and grey willow-like leaves waving on flexible boughs. For about twenty-five feet the stems of the trees in the inner part of the plantation rose up with no branches at all; but in the outer part of the wood the trees sent out branches in the light and air nearly touching the ground. It produced a curious impression to walk in the dim twilight of this Australian-African forest, and to think that this was also a wood of the Miocene period. Beautiful is not the word I should apply to its appearance; but, in exchange for bare, sun-baked earth, or deadly swamps, I must say these Eucalyptus forests are most grateful, and the smell delightfully resinous, warm, and gummy. The multitude of birds in the branches and their busy twitterings added much to the pleasant impression. I measured these trees as I walked along, and found them forty to forty-five inches in circumference; those on the borders of the wood always, of course, a few inches larger. The flower of the Eucalyptus tribe is very like the myrtle flower; it is full of honey, and attracts a multitude of flies and bees; and the birds naturally follow, for they find not only food, but thick, warm, leafy cover in winter, and shelter from the burning sun in summer. Some species of the Eucalyptus have large and very beautiful flowers; we noticed with delight the gorgeous, red, and staminous flower of the *E. tetraptera* bursting the pyramidal top of its square-sided flower-box."

An interesting communication regarding the Eucalyptus in South Africa has been forwarded to me by J. Mountfield Bennett, Esq., of Mountfield, Sussex: "I have often seen the *Eucalyptus globulus* in South Africa. It does not do well on the coast, as has also been found in Jamaica, where it was only introduced six years ago, and trees are already found there sixty feet high. Up the country in South Africa, fifty miles N.W. round Pieter-Maritzburg, we find it growing to perfection. There are plantations of it all over that district. I was staying for six months at one of these, the property of Mr. Simmons, Secretary of State, who has twenty acres planted with trees. The great drawback to cultivators in South Africa is the liability of Eucalyptus plantations to destruction by fire when the grass is burnt, which is done once a year in the Velt. Round every Boer's house you may see this tree growing from a great distance. When one is lost, as I know from experience, it is the gladdest sight a sportsman can see, their dark foliage always assuring him a night's lodging. Through the Transvaal the houses always have a few of them round the gardens. I may add that it is

said this tree never grows in South Africa from the seed dropping in a natural way; it must be gathered and sown, and when planted out must be put in the same kind of locality in which it grew in the seed-bed."

In a photograph of Pieter-Maritzburg before me it is easy to distinguish the young Eucalyptus trees from the peach and other trees growing so plentifully around the snug-looking settlers' houses. They shoot upwards, like the cypress, with a slender stem, and in the photograph have a curiously artificial look.

The weird majesty of a Eucalyptus in its native land is glowingly described by the accomplished authors of "What we Saw in Australia." They found in South Australia little variety of foliage except the gum trees, red, white, and blue; these, however, vary so much in different periods of growth, in different positions, and under different lights, that they produce very nearly the effect of stone pines, firs, elms, oaks, and especially willows. Isolated trees are found as handsome in form as our finest oaks and elms, which look dwarfed by their side. When an enclosure is cleared the trees are "ringed," i.e., stripped of their bark, in order to facilitate decay, and the aspect then presented by them is sombre in the extreme. "We often," write our authors, "passed these strange plantations; and if there chanced to be a leaden sky, throwing the skeleton-like branches into strong relief, or a heavy rain blurring and blotting out the gaunt outlines, it was difficult not to believe that we were among beings of another world." The blue gum, or *E. globulus*, is not yet abundant in South Australia. The red gum tree makes excellent fuel; the white burns, but gives little heat.

The genus *Eucalyptus* belongs to the order Myrtaceæ, and numbers about 150 species, of which about fifty are being naturalized in Algeria. Leaves of a certain fossil species have been discovered in several places in Switzerland, the beds belonging to the Miocene epoch. At Monte Bolca, in North Italy, three species have been discovered in strata of the Eocene epoch. So far as is yet known, no trace of the genus *Eucalyptus* has been found in any part of Britain.

The best descriptions of *Eucalyptus globulus* are to be found in Sir J. Hooker's "Fl. Tasmaniæ," vol. i., and in Baron Müller's "Fragmenta Phytographiæ Australiæ;" but such accounts of it as are to be found in Bentley's "Handbook of Botany" and other works of the kind will suffice for the ordinary reader.

A long gap follows in the history of the Eucalyptus after Labillardière's discovery, only occasional specimens attracting the notice of arboriculturists, who often cultivated them without knowing what they were. In England, otherwise so abundantly supplied with specimens of the Australian flora, no attention was

paid to it till within the last few years; and in a glass house belonging to the Botanical Museum of Paris, so late as 1854, a specimen was exhibited under a wrong name. In Tasmania, on the contrary, its divers uses and economic properties were early appreciated; but the real history of the Eucalyptus dates from the foundation of the colony of Victoria, about a generation and a half ago. The learned director of the Melbourne Botanical Gardens, Baron Müller, German by birth, Anglo-Australian by naturalization, whose name will ever be associated with that of the Eucalyptus, first set to work on the noble task of propagation, finding in M. Ramel, a French merchant, an equally zealous devotee to the same cause; and it is mainly owing to their conjoint efforts in the first instance that this anti-febrile tree, *par excellence*, is now spread far and wide. M. Ramel happened to visit Australia on business, and noticed in the public gardens of Melbourne a conspicuous young tree, of which he knew neither the name nor the family. "But," he writes, "I was struck by its elegance, and it became straightway an object of interest to me." He carried some seeds back to France with him, which were at once planted, and the extraordinarily rapid growth of the seedlings excited no little curiosity. In some cases they shot upwards at the rate of a yard in a few months, while their graceful bluish-green foliage made them agreeable additions to public gardens. M. Ramel, a man of business and no botanist to begin with, addicted himself to the Eucalyptus with an ardour only seen in scientific research. He studied it under all its aspects, and predicted the grand part it was to play in the economic history of the natural world. As one of his friends has written, he believed in the Eucalyptus as optimists believe in the final triumph of good over evil upon earth. In imagination he saw the plains and marshes of Algeria covered with plantations and forests, fever and malaria disappearing, climate and soil undergoing wondrous transformations, happy populations flourishing where fever, pestilence, and ill-rewarded toil had hitherto decimated the pioneers of civilization. And, fantastical as those dreams seemed to others then, they have in great part come true, as this history will show. Baron Müller and M. Ramel put their shoulders to the wheel, and from 1862 the planting of the Eucalyptus was vigorously carried on in various places, notably in Algeria. At first saplings were transplanted from the Jardin d'Acclimatation, but it was soon discovered that seed-sowing offered the quickest and surest means of propagation. Seeds, therefore, were sent by Baron Müller in great quantities; and M. Ramel found active coadjutors in MM. Trottier, Cordier, Bodichon, and other leading colonists. The name of the distinguished botanist Durando will ever be associated also with this good work in the colony. These gentlemen soon convinced

themselves that not only did the *Eucalyptus globulus* offer a source of industrial wealth to the colony as timber, but also, if planted on a sufficiently extensive scale, a guarantee against the hitherto invincible enemy, malaria. How assiduously planting was carried on may be judged by one fact. In 1862 not a single seed had been sown in Algeria, whereas at the present time we find there many hundred thousand trees, two millions having been sown and planted in the colony altogether. Large numbers have died in their early state, greater care being then required than was always given; and the Arabs also are very destructive to the young plantations, the women and children often breaking and mutilating the trees when in want of brooms or branches. These trees vary in height from fifty to sixty feet, and in some cases have been known to grow to a height of thirty yards in ten years; two yards a year is no unusual growth. Individual efforts, however, could not have brought about such large results, and the Algerian Government, as well as public companies, have seconded them in many districts. It was found that wherever the Eucalyptus was planted abundantly, sanitary conditions improved, so that alike a love of science and humanity stimulated the work.

Many species have been and are being daily tried, but at present the large plantations consist principally of the *Eucalyptus globulus*. The species *E. colosea*, which is a hardier tree in the sun than the *E. globulus*, flourishes in the desert at Laghouat. These fragrant Australian forests in the midst of African deserts now form one of the marvels of Algerian travel; but during my two visits eleven or twelve years ago the very name of Eucalyptus was only familiar to a few *savants*, and not a single tree was growing on large tracts now green and umbrageous with the familiar bluish-green foliage and slender branches.

But not in Algeria alone has the work of propagation been vigorously carried on, though the French-African colony may be regarded as the adopted country of the Blue Gum Tree. On the coast of the Riviera, in the South of France and Spain, in Corsica, in the jungles of Ceylon, in the Transvaal, and other parts of South Africa, as also in Jamaica, the Eucalyptus has been planted by the arboriculturist or the colonist, and always with the best results. A year or two ago very interesting letters appeared in a Ceylon newspaper on the effect of Eucalyptus-planting in the jungle. Wherever such experiments had been carried on to any extent jungle fever showed a perceptible tendency to diminish. Its introduction into Valencia is due to the combined efforts of M. Ramel and a countryman of our own, equally indefatigable in the same cause, Mr. Wilson. At the time of a journey made by them in Spain the malaria was raging.

Many trees were planted in the most unhealthy spots; and their value was so soon recognized by the peasants, that they would steal the leaves for the purpose of making decoctions, and called the Eucalyptus *l'arbre à la fièvre*. Now single trees and plantations are found near Seville, between Seville and Granada, at Granada and Malaga, also near Lisbon. Nice, Monaco, Hyères, Cannes can now boast of their Eucalyptus plantations, especially in private gardens, where they are highly ornamental; and the Roman Campagna, that hotbed of fever, might without doubt be considerably modified if planting were undertaken on an extensive scale. Hitherto in Italy little has been done, though Garibaldi and other leading men have greatly interested themselves in the subject. The Trappist monks in the Campagna, however, have sanified their immediate district by extensive Eucalyptus plantations, which they proudly show to visitors, stating that formerly they were constantly being stricken down by malaria, whilst now it is almost unknown. Again, a little railway station in the Var, near Cannes, was at one time so terribly unhealthy, in consequence of miasma, that the station-master had to be changed every two years. Eucalyptus trees have been planted in considerable quantities round the station, and now it is no longer necessary to make these frequent changes. It is proposed to try Eucalyptus plantations in Cyprus, and we trust the scheme may be carried out.

Among ourselves efforts to naturalize the Eucalyptus out of doors have almost always failed; and the curious must visit the glass houses at Kew to familiarize themselves with this famous tree. The cold English winters and springs kill the saplings even in sheltered situations, so that we may hardly hope to see Romney Marsh or other aguish tracts metamorphosed after the manner of Algerian plains. The Eucalyptus requires as mild a climate as the orange, its zone having now been pretty accurately defined by botanists.

It is hardly necessary to remind the reader of the sanitary effect of trees or the unwholesomeness of treeless wastes. All who have travelled will recall many instances in point—Madrid, for example, which, in consequence of its arid environment, possesses one of the unhealthiest climates in Europe. Again, in Corsica the same physical conditions have been brought about by human interposition, the once fertile plains of Niolo now being completely denuded of trees, to the great detriment of its inhabitants; whereas in the sixteenth century the whole country was covered with woods and forests.

In Italy the destruction of forests in many places has been followed by the scirocco. Professor Ansted cites in one of his works the example of a pine forest near Ravenna. The forest was cut down, and the hot wind immediately appeared; it was

replanted, and no more scirocco occurred. The mistral, in the South of France, which did not occur till after the clearing of the Cevennes—the unhealthiness caused in Alsace by the felling of trees on a large scale—the aridity of Provence, once the garden of France, due to the same causes, are all cases in point.

At the time of the Revolution, writes Michelet, began a general destruction of forests in France. Trees were sacrificed for the most trifling uses. Two pines would be felled for the making of a pair of sabots! Some curious statistics are given by another writer on the effect of trees upon population, it being shown that in some departments the population has steadily decreased since the clearing of the forests. So late as 1853 the préfet of the Basses Alpes wrote officially: "If prompt and energetic measures are not taken to prevent this destruction, we shall be able to foretell almost exactly when the French Alps will become a desert in consequence of this iconoclasm." But no instance is more striking than that of Algeria. At the time of the conquest the whole of the Sahel and a great part of the Metidja were covered with wood and scrub, which not only prevented undue evaporation from the earth, but also acted as a condenser of moisture, causing refreshing dews and rains. The destruction of forests, dating from 1845, has materially changed the atmospheric conditions in those districts, and nothing but ignorance, cupidity, and fanaticism can account for the wholesale forest-burning still witnessed in Tunis and Algeria. The Arabs are persistent incendiarists, partly because the system enters into their notions of agriculture, but chiefly to spite and injure the constantly widening circle of European colonization. Forty thousand hectares of forest were thus destroyed in the year 1865 alone. Now, it has been found by experience that the Australian Blue Gum Tree, or *Eucalyptus globulus*, answers the purpose of *réboisement*, or replanting, in Algeria better than any other at present known, and many leading colonists, as we have seen, have brought wealth, science, and philanthropy to bear on the question. Foremost of these must be named M. Trottier, who claims pre-eminence for the Eucalyptus, on sanitary as well as economic grounds, seeing not only in its anti-febrile and climatic properties the surest remedy for malaria, but in the valuable quality of its timber a perpetually increasing source of wealth to the colony. In his various pamphlets, severally entitled "Influence des arbres sur la pluie," "Notes sur l'Eucalyptus," "Rôle de l'Eucalyptus en Algérie," &c., these matters are fully dealt with, and his conclusions may be summed up as follows:—The results of special observations made by the pluviometer show that forests draw down a greater abundance of rain than cultivated open land; that even under trees the water reaching the

soil is larger in bulk than that falling upon unsheltered ground; in fact, that it is by means of large plantations that hot, dry climates are moistened and made habitable for Europeans. Secondly, M. Trottier brings abundant evidence to prove that of all other trees the Eucalyptus is best adapted for bringing about the physical change so necessary in Algeria, the aromatic odour of its leaves possessing strong anti-febrile qualities, whilst its timber, bark, and oil open up new sources of wealth and industry. Thirdly—and this is a vital point in the question at issue—it is unrivalled for its swiftness of growth. Large numbers are found in the South of France, partly because the elegance of the tree and the abundance of shadow make it desirable in private gardens, but chiefly because none other springs up so fast. You build your villa, sow your Eucalyptus seeds, and in seven years' time may expect to see a flourishing grove of forest trees fifty feet high. In some cases they have been known to reach a height of thirty yards in ten years, and two yards a year is no unusually rapid growth. There is something extremely fascinating in results so rapid and on so large a scale. Here indeed we do not plant trees for posterity, but for ourselves; and, granted favourable conditions, with a packet of seeds no larger than a mustard-seed, we may confidently look forward to the enjoyment of our forest in a few years; a forest, moreover, not only ornamental but useful, attracting the birds and the bees, and dispensing healthful influences around. Opinions vary as to the manner in which these sanitary influences are effected. The aromatic oil or essence distilled from the leaves may be compared to camphor, peppermint, and other antiseptics, whilst the bark possesses many of the qualities of quinine.

A very large number of experiments have been made in support of these theories, with almost invariable success. M. Trottier cites his own farm as an instance of the anti-febrile properties of the Eucalyptus, where, except in two cases, mainly owing to imprudence, no fever had occurred since the growing up of his plantations. Consul Playfair's report for 1877, quoted in the *Times*, mentions a single mining company having planted 100,000 trees at Mokta-el-Hadiet. Previously the workmen could not remain there during the summer on account of the unhealthiness of the place; those who attempted to do so died, and it was necessary to convey the labourers to and fro by rail every morning. Since the planting of the Eucalyptus the workmen are able to live on the spot all the year round. The company of military engineers alone have planted a large tract with 102,060 trees, now forming a flourishing young forest of eight years' growth. Algerian travellers who happen, like the present writer, to have traversed the plain of the Sig, in the province of Oran,

at the unwholesome season of ploughing, when the upturned soil teems with miasma, will not soon forget the fetid odour emanating from the marshy ground, nor the doom written on the faces of the people. 'The fever! the fever!' was the continual cry that rang in our ears throughout our journey; and the poor colonists begged us for quinine, which we could only give, of course, in minimum doses. Twenty years hence this same insalubrious plain of the Sig may be transformed into a region as healthful as the high grounds of Sussex or Surrey by means of the Eucalyptus.

To M. Carlotti, a Corsican doctor, we are indebted for a series of extensive and highly instructive observations in this field. During a summer and winter when intermittent fever was more common than usual in Corsica, M. Carlotti was enabled to test fully the powers of his Eucalyptus medicines, generally beginning with small doses and increasing them after renewed trials. The results obtained from infusions and decoctions of the leaves were most satisfactory. In some cases the remedy was more efficacious than quinine even, preventing a relapse, which quinine often fails to do. A fellow-countryman of Dr. Carlotti's, M. Tedeschi, was induced to follow his example, and wrote to him afterwards as follows: "I am like St. Thomas, and wished to convince myself by repeated trials before declaring my opinion. The results have been entirely satisfactory. Remember that I have never used the new medicines except in cases which quinine failed to cure. There have been failures and relapses, but the number of cures is large enough to place the decoction of Eucalyptus on a par with quinine as a tonic."

No less conclusive is the evidence of Dr. Miergues, of Bouffarik, Algeria, published in the "Science pour Tous" for January 15, 1870, wherein he gives a list of cures effected not only in human beings but animals, in the latter especially skin diseases, by means of a kind of Eucalyptus tar. For it must not be supposed that malaria, ague, and intermittent fevers are the only maladies amenable to these remedies. Dr. Miergues is the author of twenty-four medical preparations, in the form of tonics, stimulants, medicaments, plasters, powders, &c., and since that time many others have been made and are gradually getting into use. In the South of France and in Rome it is now a common practice to put a few dried Eucalyptus leaves in the light wine of the country as a tonic, and also to induce sleep in feverish patients by placing a young Eucalyptus plant near the bedside. In Algeria the medical uses of the Eucalyptus are constantly on the increase.* A few leaves put in a bath of hot

* See a paper on this subject, contributed by the present writer to the "Pall Mall Gazette"—"Medical Uses of the *Eucalyptus globulus*," January 16, 1875.

water are found to alleviate rheumatic and neuralgic pains, also the extreme debility following an attack of malaria. Lozenges are used for throat and lung disease, and there are also various specifics for other maladies in the form of cigars. As antiseptics Eucalyptus oils and soaps are exceedingly efficacious, and it is interesting to find them making way here. A chemist, on whose counter I saw some of this most fragrant soap, at Hastings, the other day, assured me that it had been in great demand for twelve months. It is especially recommended for use in the sick room.

Many specimens of these medical, and also of artistic preparations have been sent to me from Algeria, and all are characterized by a grateful fragrance, once inhaled never forgotten. I may mention *inter alia*, the sticking-plaster, tooth-powder, toilet-water, tracing-paper, oil for preserving natural and anatomical specimens, veneer, the list being too long to give entire. Naturally it is in Algeria, the adopted country of the Eucalyptus, that these investigations have been carried on with the greatest vigour, though in Paris, especially since the Algerian Exhibition, held two years ago, much interest has been excited on the subject. We may therefore expect many new and important additions to our knowledge of the resources of this wonderful tree.

It has been mentioned that Labillardière recognized the value of the Eucalyptus timber, which for hardness and durability is said to rival teak-wood. When we consider that it attains in six or seven years the dimensions of the oak in twenty, and may be expected in its twentieth year to furnish such logs of timber for shipbuilding and other purposes as could not be supplied by an oak under a hundred years old, we can understand the enthusiasm of planters. Consul Playfair, in the report already alluded to, mentions that when he wished, a short time since, to send a Eucalyptus tree four or five years old to England, its great length made it impossible to convey it in a boat to the steamer, and the boatman decided on towing it alongside. It sank, however, in the sea, and divers had to be employed in raising it. After it has been properly seasoned its specific gravity becomes less, and it then floats in water. The Consul is convinced that no other culture offers such prospects of success, provided the cultivator can afford to wait some time for his returns.

M. Trottier is the author to consult on this subject; and though his calculations read like the dreams of a visionary, they are without doubt based on scientific data. M. Carlotti, again, calculates that in planting large tracts in Corsica with Eucalyptus trees, the plantations would produce large profits in a few years; and we learn that the annual exportation of Euca-

lyptus timber from Tasmania reached, a few years ago, the large sum of 800,000*l*., which may give some idea of its value in that country. Of course the extraordinary rapidity of growth enters largely into these calculations.

Next to suitability of climate the soil has to be considered. Not only does it flourish in marshy grounds and swamps, but, as Baron Müller shows us to be the case in its native land, in dry and arid wastes, thus rendering it equally adapted to the sun-baked mountain-sides and swampy plains of Algeria. The Eucalyptus, indeed, resists the summer droughts, and profits by the rains of spring, winter, and autumn, wherever the mildness of the temperature enables it to flourish.

Specimens of Eucalyptus timber were seen at the London Exhibition of 1862, one of which measured twenty-three yards in length, with a circumference of three and a half. The best whalers cruising in the southern seas, are made of Eucalyptus wood. It is largely used in ship-building generally, and in the construction of railway sleepers, bridges, jetties, viaducts; less so in carpentry, on account of the difficulty of working it up on a small scale. Such obstacles, however, may be overcome, and we may hope ere long for a pleasing variety of art furniture in the shape of Eucalyptus upholstery. This tree, moreover, so productive of solid benefits in the shape of timber, abounds in lighter graces, attracting the birds by its ample foliage, and the bees by means of the abundant honey contained in its flowers. Formerly the bee was unknown in Australia, but it has been speedily domesticated, in consequence of the Eucalyptus flowers. Such honey should surely rival that of the far-famed Hymettus. The history of the Eucalyptus is, indeed, one of those fairy-tales of Science which fills the mind with wonder and delight. Here we have in a seed not larger than a mustard-seed not only a source of commercial wealth, and therefore national prosperity, but, what is far more important, of the health of coming generations, and the amelioration of those physical conditions in which man is compelled to live. Just as, in the intellectual history of society, the word may be a lever of immeasurable power, lifting the minds of others to higher regions of thought, enlarging man's spiritual domains, so, in the natural history of the world, the seed is a mighty agent for good, spreading beneficent influence around, revealing new scientific triumphs, bestowing undreamed of largesses on all.

Whether, therefore, we behold the *Eucalyptus globulus* in an English glass-house, or in the more favoured lands of its adoption, alike the slender sapling, with its silvery blue-green leaves, and the lofty forest tree spreading abundant shadow, affords a worthy subject of wonder and admiration. But we must remember that Nature has not done all. Were it not for the

devotedness and zeal of the first believers in the Eucalyptus, it might still have remained a mere ornament in public gardens and conservatories. All honour, then, to those who have consecrated their time, thought, and worldly goods to the cause of man's best friend, the tree!

NOTE.—The illustration appended to this sketch (Plate VIII.) is reduced one half from an original water-colour drawing by an accomplished Algerian artist, Madame Mérian.

THE EXTINCT BRITISH WOLF.

By J. E. HARTING, F.L.S., F.Z.S.

(*Concluded from* p. 269.)

Historical Evidence.—Ireland.

FROM the scanty and more or less inaccessible nature of the records relating to the natural history of Ireland, compared with what exists in the case of England and Scotland, the result of a search for materials for a history of the wolf in Ireland has proved less satisfactory than could have been wished. Nevertheless, some curious fragments of information on the subject have been collected from various sources, and are now brought together for the first time.

There is abundant evidence to show that wolves formerly existed in great numbers in Ireland, and that they maintained their ground for a longer period there than in any other part of the United Kingdom. In bygone ages they must have fared sumptuously amongst the herds of reindeer and Irish elk, which at one time were contemporary with them; and the discovery of numerous skeletons, often entire herds of deer, imbedded in the mud of ancient lakes, has led to the surmise that these animals probably perished in this way in their attempts to escape from packs of pursuing wolves.

Giraldus Cambrensis, who lived in the reigns of Henry II., Richard I., and John, and who visited Ireland in 1183 and again in 1185–6, when he accompanied Prince John there, has left a curious account of the wild animals then existing in Ireland, amongst which is included the wolf. He adds, "the wolves often have whelps in the month of December, either in consequence of the great mildness of the climate, or rather in token of the evils of treason and rapine, which are rife here before their proper season." *

* "Topographia Hiberniæ," lib. ii., cap. xxvi., p. 726. Ed. Dimock, vol. v., p. 112. And not only wolves, but crows and owls had young at Christmas. Tom. cit., p. 112.

In the "Polychronicon" of Ranulphus Higden, the monk of Chester, who died about 1360, we have a later account of the Irish fauna, and in this also the wolf figures. Thus he says:—"*Terra hæc magis vaccis quam bobus, pascuis quam frugibus, gramine quam grano fecunda. Abundat tamen salmonibus, murœnis, anguillis, et cœteris marinis piscibus; aquilis quoque, gruibus, pavonibus, coturnicibus, niso, falcone et accipitre generoso. Lupos quoque habet, mures nocentissimos; sed et araneas, sanguisugas, et lacertas habet innocuas. Mustelas quoqu parvi corporis sed valde animosas possidet.*"* This passage is thus rendered by his translator, John Trevisa (A.D. 1357–1387), and adopted by Caxton in his "Cronycles of England," 1480:—"In this lond beeth mo kyn than oxen, more pasture than corne, more grass than seed. There is grete plente of samon, of lampreyes, of eles, and of other see fisch: of egles, of cranes, of pekokes, of corlewes, of sparhaukes, of goshaukes, and of gentil faucouns, *and of wolfes*, and of wel shrewed mys. There beeth attercoppes, blood-soukers, and enettes that dooth noon harm," &c.† Some translators and later copyists have here and there singularly perverted the original meaning of this passage by blunders and mistranslations. Amongst these may be mentioned the author or authors of "The Book of Howth," a small folio in vellum of the sixteenth century, written in different hands, and preserved amongst the Carew MSS. (vol. 623), in the Lambeth Library.‡

Campion, whose "History of Ireland" was published in 1570, refers to the chase of the wolf there with wolf-hounds. "The

* "Polychronicon Ranulphi Higden, Monachi Cestrensis." Ed. Babington (Master of the Rolls Series), vol. i. pp. 334, 335.

† Some little interest attaches to this passage from the curious assemblage of animals named in it. At the period referred to "Cranes" seem to have been common enough in Ireland: "*in tanta vero numerositate se grues ingerunt, ut uno in grege centum, et circiter hunc numerum frequenter invenias*" (Topog. Hibern. Ed. Dimock, v. 46). By "pekokes" (*pavonibus*), it would seem the Capercaillie is intended. "*pavones silvestres hic abundant,*' says Giraldus (tom. cit. p. 47). "*Coturnicibus*" should be rendered "quails," not "curlews." "*Mures nocentissimos*" are not necessarily shrew-mice, which are insectivorous. In all probability that destructive field-mouse, the short-tailed Vole, *Arvicola agrestis*, is referred to. By reading "araneos" (shrews) for "araneas" (spiders), some confusion is accounted for. "Attercoppes" is the translation of *araneas*. Jamieson, in his "Scottish Dictionary," gives "Atter-cap," "Attircop," spider, with two variants—Northumberland, "Attercop," and Cumberland, "Attercob," a cobweb. A. S. atter coppe, from atter, *venenum*, and copp, *calix*; receiving its denomination partly from its form, and partly from its character; *q.* a cup of venom. By "Bloodsuckers," of course, leeches are meant: for "enettes" *lacertas*, we may read "euettes" or "evettes," i.e. efts, that do no harm.

‡ *cf.* Brewer and Bullen, Calendar Carew MSS., "The Book of Howth," p. 31.

Irish," he says, "are not without wolves, or greyhounds to hunt them; bigger of bone and limme than a colt." *

Sir James Ware, in his "Antiquities of Ireland" (1658), notices "those hounds which, from their hunting of wolves, are commonly called 'wolf-dogs,' being creatures of great strength and size, and of a fine shape."

Ray has described the Irish wolf-dog as a tall, rough greyhound; so also has Pennant, who descants at some length on his extraordinary size and power.

In a privy seal from King Henry VIII. to the Lord-Deputy and Council of Ireland, † his Majesty takes notice of the suit of the Duke of Albuquerque, of Spain (of the Privy Council to Henry VIII.), on behalf of the Marquis Desarrya and his son, "that it might please his Majesty to grant to the said Marquis and his son, and the longer liver of them, yearly, out of Ireland, two goshawks and four greyhounds," and commands the Deputy for the time being to order the delivery of the hawks and hounds, and to charge the cost to the Treasury.

In November, 1562, as we learn from the State Papers relating to Ireland, ‡ the Irish chieftain, Shane O'Neill, forwarded to Queen Elizabeth, through Robert Dudley, Earl of Leicester, a present of two horses, two hawks, and two Irish wolf-dogs. In 1585, Sir John Perrott, who was Lord-Deputy of Ireland from January, 1584, to July, 1588, § sent to Sir Francis Walsingham, then Secretary of State in London, "a brace of good wolf-dogs, one black, the other white."

Again, in 1608, we find that Irish wolf-hounds were sent from Ireland by Captain Esmond, of Duncannon, to Gilbert, seventh Earl of Shrewsbury. ||

These dogs were considered very valuable, and were highly thought of by those who received them as presents; but some years later, when owing to the great increase in the number of wolves in some parts of Ireland, their services were more than ever required to keep down these ferocious animals, a law, presently to be noticed, was passed to prohibit their exportation.

In Robert Legge's "Book of Information," compiled in 1584 by order of Sir John Perrott, the above named Lord-Deputy of Ireland, "for the reformation of the civil government of that realm," it is recommended, *inter alia*, that "for the destruction of ravening and devouring wolves, some order might be had, as

* *See* also Holinshed, "Descript. Irel." 1586, and Camden, "Britannia," vol. ii., p. 1312 (Gibson's Ed.).

† Rot. Canc. Dec. 9, 36 H. 8, *dorso*.

‡ Eliz., vol. vii., No. 40, in Pub. Rec. Off.

§ Ibid., vol. cxx., No. 12.

|| "Archæol. Æliana," vol. ii. p. 226.

when any lease is granted, to put in some clause that the tenant endeavour himself to spoil and kill wolves with traps, snares, or such devices as he may devise." *

About this time, it is said, wolves committed great devastation amongst the flocks in Munster. After the destruction of Kilmallock by James Fitzmaurice, in 1591, that place is stated to have become the haunt of wolves.

For some account of their ravages during Desmond's rebellion, the reader may be referred to O'Sullivan's "Compendium Historiæ Catholicæ Hiberniæ," 1621 (lib. viii., cap. 6).

At a later period, according to Fynes Moryson, who was Secretary to Lord-Deputy Mountjoy, and who wrote a "History of Ireland from 1599 to 1603," the cattle had to be driven in at night, "for fear of thieves (the Irish using almost no other kind of theft), or else for fear of wolves, the destruction whereof being neglected by the inhabitants, oppressed with greater mischiefs, they are so much grown in numbers as sometimes on winter nights they will come and prey in villages and the suburbs of cities." †

In May, 1594, Lord William Russell was appointed Lord-Deputy of Ireland by Queen Elizabeth. From entries in his "Journal," extending from "June 24, 1594, to May 27, 1597," it appears that both he and Lady Russell, who accompanied him to Ireland, frequently participated in the pleasures of the chase, and amused themselves at different times with hawking, fishing, and hunting. ‡ Under date May 26, 1596, it is recorded: "My Lord and Lady rode abroad a hunting the wolf." As the Vice-regal Court was then located at Kilmainham, almost within the city of Dublin, it would appear that the wolf in question was to be found at no great distance beyond the city walls.

Sir Arthur Chichester, writing to Sir John Davys, March 31, 1609, in reference to the pending plantation of Ulster, incidentally remarks that "if the Irish do not possess and inhabit a great part of the lands in some of those escheated countries, none but wolves and wild beasts would possess them for many years to come; for where civil men may have lands for reasonable rents in so many thousand places in that province, and in this whole kingdom, they will not plant themselves in mountains, rocks, and desert places, though they might have the land for nothing." §

In the reign of James I. it would seem that active measures

* Carew MSS., vol. 607, p. 115. Brewer and Bullen, Calendar of Carew MSS., Eliz., p. 401.

† Moryson, "Hist. Irel.," Dublin ed., 1735, vol. ii., p. 367.

‡ Preserved amongst the Carew MSS. at Lambeth Palace, vol. 612.

§ State Papers, Ireland, in Record Office, vol. 226, 58.

were devised for the destruction of wolves in Ireland, and the following "Heads of a Bill in the Irish Parliament, 1611," will be found preserved amongst the Carew MSS., formerly in the Record Office, but now at Lambeth Palace :* "An Act for killing wolves and other vermin, touching the days of hunting, the people that are to attend, who to be their director, an inhibition not to use any arms. The Lord Deputy or Principal Governor to prohibit such hunting if he suspect that such assemblies by colour of hunting may prove inconvenient." This proposed act, however, seems never to have become law, for no mention of it is made in the eight volumes of Irish Statutes published by authority in Dublin in 1765. It is not surprising therefore that the ravages of the wolves in Ireland continued. In 1619 their numbers in Ulster compelled people "to house their cattle in the bawnes of their castles, where all the winter nights they stood up to their bellies in dirt. Another reason is to prevent thieves and false-hearted brethren who have spies abroad, and will come thirty miles out of one province into another to practise a cunning robbery."† In 1641 and 1652 wolves were particularly troublesome in Ireland, and in the latter year the following Order in Council was issued by Cromwell, prohibiting the exportation of wolf-dogs:—

"*Declaration against transporting of Wolfe Dogges.*

"Forasmuch as we are credibly informed that Wolves doe much increase and destroy many cattle in several partes of this Dominion, and that some of the enemie's party, who have laid down armes, and have liberty to go beyond sea and others, do attempt to carry away several such great dogges as are commonly called *wolfe dogges*, whereby the breed of them which are useful for destroying of wolves would (if not prevented) speedily decay. These are therefore to prohibit all persons whatsoever from exporting any of the said dogges out of this Dominion; and searchers and other officers of the Customs, in the several partes and creekes of this Dominion, are hereby strictly required to seize and make stopp of all such dogges, and deliver them either to the common huntsman, appointed for the precinct where they are seized upon, or to the governor of the said precinct. Dated at Kilkenny, April 27, 1652."

The following year another Order in Council was made which ran as follows:—

* Carew MSS., vol. 629, p. 35. *See* also Hamilton's "Calendar of State Papers relating to Ireland," Jac. I., sub anno, p. 192.

† Gainsford's "Glory of England," p. 148.

"*Declaration touching Wolves.*

"For the better destroying of wolves, which of late years have much increased in most parts of this nation, it is ordered that the commanders in chiefe and commissioners of the Revenue in the several precincts doe consider of, use, and execute all good wayes and meanes how the wolves in the counties and places within the respective precincts may be taken and destroyed; and to employ such person or persons, and to appoint such daies and tymes for hunting the wolfe, as they shall adjudge necessary. And it is further ordered that all such person or persons as shall take, kill, or destroy any wolfes and shall bring forth the head of the wolfe before the said commanders of the revenue, shall receive the sums following, viz., for every bitch wolfe, six pounds;* for every dog wolfe, five pounds; for every cubb which preyeth for himself, forty shillings; for every suckling cubb, ten shillings. And no wolfe after the last September until the 10th January be accounted a young wolfe, and the Commissioners of the Revenue shall cause the same to be equallie assessed within their precincts.

"Dublin, June 29, 1653."†

The assessments here ordered fell heavily in some districts. Thus in December, 1665, the inhabitants of Mayo County petitioned the Council of State that the Commissioners of assessment might be at liberty to compound for wolfe-heads; which was ordered accordingly.

In 1662, as appears by the Journals of the House of Commons, Sir John Ponsonby reported from the Committee of Grievances that a bill should be brought in "to encourage the killing of wolves and foxes in Ireland."

In the "Travels of the Grand Duke Cosmo III. in England," 1669 (p. 103), the author speaks of wolves as common in Ireland, "for the hunting of which the dogs called 'mastiffs' are in great request."

O'Flaherty in his "West or H'Iar Connaught" (1684) enumerates the wild animals which were to be found in that district in his day, and names "*wolves*, deere, foxes, badgers, hedgehogs, hares, rabbets, squirrells, martens, weesles, and the amphi-

* The price paid in Sutherlandshire, in 1621, was 6*l.* 13*s.* 4*d.* *Cf. antea*, p. 257.

† These documents were extracted from the original Privy Council Book of Cromwell's government in Ireland, preserved in Dublin Castle, and are quoted by Hardiman in his edition of O'Flaherty's "West or H'Iar Connaught," p. 180.

bious otter, of which kind the white-faced otter is very rare." Hardiman, in a note to his edition of this work (1846), says: "When our author wrote (1684), and for some years afterwards, wolves were to be found in Iar Connaught, but not in such numbers as in the early part of that century. The last wolf which I have been able to trace here was killed in the mountains of Joyce country, in the year 1700. After the wars of 1641 the ravages of the wolves were so great throughout Ireland as to excite the attention of the State. 'Wolf-hunters' were appointed in various districts, and amongst others in Iar Connaught, who helped to rid the country of these ferocious animals."*

In an account of the British Islands, published at Nuremberg in 1690, the wilds of Kerry are referred to as harbouring wolves and foxes;† and in the reign of William and Mary, Ireland was sometimes called by the nickname of "Wolf-land." Thus in a poem on the battle of La Hogue, 1692, called "Advice to a Painter," the terror of the Irish army is described:—

A chilling damp,
And wolf-land howl runs through the rising camp.

"Three places in Ireland are commemorated, each as having had the last Irish wolf killed there, namely, one in the south, another near Glenarm, and the third, Wolf-hill, three miles from Belfast."‡ The one in the south is probably that referred to in Edwards's "Cork Remembrancer" (p. 131), wherein the following entry occurs: "This year (1710) the last presentment [to the Grand Jury] for killing wolves was made in the county of Cork."§ In the old "Statistical Account of Scotland," however, edited by Sir John Sinclair, it is stated (vol. xii., p. 447) that the last was killed in Ireland in 1709.

The great woods of Shillela, on the confines of Carlow and Wicklow, now the property of Earl Fitzwilliam, are said to have held wolves until about the year 1700, when the last of them was destroyed in the neighbourhood of Glendaloch.‖

In a poem, in six cantos, published as late as 1719, and entitled, "MacDermot, or the Irish Fortune-Hunter," "wolf-hunting" and "wolf-spearing" are represented as common sports in Munster. Here is an extract:—

* Hardiman, op. cit., p. 10, note.

† This work the writer has not seen. It is quoted by Macaulay, "Hist. Engl.," vol. iii., p. 136.

‡ Thompson, "Nat. Hist. Ireland," vol. iv., p. 34.

§ *See* also Scouler, 'Journ. Geol. Soc.,' Dublin, vol. i., p. 226.

‖ Mackenzie's Natural History, p. 20. This volume, published in London in modern times, is undated.

It happen'd on a day, with horn and hounds,
A baron gallop'd through MacDermot's grounds,
Well hors'd, pursuing o'er the dusty plain
A wolf, that sought the neighbouring woods to gain:
Mac hears th' alarm, and, with his oaken spear,
Joins in the chase, and runs before the peer,
Outstrips the huntsman, dogs, and panting steeds,
And, struck by him, the falling savage bleeds.

The crest of the O'Quins of Munster is "a wolf's head, erased, argent," possibly perpetuating the prowess of some former noted wolf-hunter in that ancient family.

The author of "The Present State of Great Britain and Ireland," printed in London in 1738, wrote at that date, "Wolves still abound too much in Ireland; they pray for the wolves, least they should devour them."

In Smith's "Ancient and Modern State of the County of Kerry," 1756 (of which book Macaulay said, "I do not know that I have ever met with a better book of the kind and of the size," "Hist. Engl.," iii. 136), the author, speaking of certain ancient enclosures, observes (p. 173) that "many of them were made to secure cattle from *wolves*, which animals were not entirely extirpated until about the year 1710, as I find by presentments for raising money for destroying them in some old grand-jury books."

Traces of old circular entrenchments, into which cattle and sheep were driven for protection from wolves, are still to be seen in many parts of Ireland, especially in the south. One of these, in the county Tyrone, will be noticed presently.

In Harris's edition of Sir James Ware's "Works" (Dublin, 1764), the editor, commenting upon the passage, "I shall but just hint at the eagerness of the Irish in the chase, as in hunting wolves and stags," remarks in a footnote (p. 165), "So said in the year 1658. But there are no wolves in Ireland now." This statement in turn may be controverted, upon very respectable authority, but the conflict of evidence renders it very difficult to fix with certainty the precise date at which the animal became extinct.

The following account is given of the destruction, by a noted wolf-hunter, of the last wolves in the county Tyrone.

"In the mountainous parts of the county Tyrone, the inhabitants suffered much from wolves, and gave as much for the head of one of these animals as they would now give (1829) for the capture of a notorious robber on the highway. There lived in those days an adventurer who, alone and unassisted, made it his occupation to destroy those ravagers. The time for attacking them was at night. There was a species of dog kept

for the purpose of hunting them, resembling a rough, stout, half-bred greyhound, but much stronger.

"In the county Tyrone there was then a large space of ground inclosed by a high stone wall, having a gap at the two opposite extremities, and in this were secured the flocks of the surrounding farmers. Still, secure though this fold was deemed, it was entered by the wolves, and its inmates slaughtered.

"The neighbouring proprietors having heard of the noted wolf-hunter above-mentioned, by name Rory Carragh, sent for him and offered the usual reward, with some addition, if he would undertake to destroy the two remaining wolves that had committed such devastation. Carragh, undertaking the task, took with him two wolf-dogs and a little boy, the only person he could prevail on to accompany him, and, at the approach of night, repaired to the fold in question.

"'Now,' said Carragh to the boy, 'as the wolves usually attack the opposite extremities of the sheepfold at the same time, I must leave you and one of the dogs to guard this one, while I go to the other. He steals with all the caution of a cat; nor will you hear him, but the dog will, and will positively give him the first fall. If you are not active when he is down, to rivet his neck to the ground with this spear, he will rise up and will kill both you and the dog.'

"'I'll do what I can,' said the boy, as he took the spear from the wolf-hunter's hand.

"The boy immediately threw open the gate of the fold, and took his seat in the inner part, close to the entrance, his faithful companion crouching at his side and seeming perfectly aware of the dangerous business he was engaged in. The night was very dark and cold, and the poor little boy being benumbed with the chilly air, was beginning to fall into a kind of sleep, when at that instant the dog, with a roar, leaped across him and laid his mortal enemy upon the earth. The boy was roused into double activity by the voice of his companion, and drove the spear through the wolf's neck, as he had been directed; at which time Carragh made his appearance with the head of the other." *

In an interesting article on the Irish wolf-dog, published in "The Irish Penny Journal" for 1841 (p. 354), the writer says: †

"I am at present acquainted with an old gentleman between eighty and ninety years of age, whose mother remembered wolves to have been killed in the County of Wexford about the years 1730–40, and it is asserted by many persons of weight

* "The Biography of a Tyrone Family" (Belfast, 1829), p. 74.

† This article, published under the initials of H. D. R., has since been admitted to have been written by H. D. Richardson, author of "The Dog: its Origin, Natural History, and Varieties," in which work it has been embodied with additions, 1848.

and veracity that a wolf was killed in the Wicklow mountains so recently as 1770."

A few years since, Sir J. Emerson Tennent wrote to a contemporary on this subject as follows:—

"Waringstown, in the county Down, on the confine of the county of Armagh, takes its name from the family of Waring, which, in the reign of Queen Mary, fled to Ireland from Lancashire to avoid the persecution of the Lollards. At the close of the seventeenth century the Waring of that day was a member of the Irish Parliament; and his eldest son, Samuel Waring, was born about the year 1699, and died at a very advanced age in 1793. He was succeeded by his nephew, the Very Reverend Holt Waring, Dean of Dromore, who was born in 1766, and whom I had the honour to know. With him I happened to be travelling through the Mourne mountains, in the county of Down, on our way to the Earl of Roden's, about the year 1834 or 1835, when the conversation turning upon the social condition of Ireland in the previous century, he told me that a foal belonging to his uncle had been killed by a wolf in the stable at Waringstown, and that he, when a boy, had heard the occurrence repeatedly adverted to in the family circle. The dean was a man of singularly acute mind and accurate memory, and unless this statement of his be altogether a delusion, this would seem to be the last recorded appearance of a wolf in Ireland."

The last piece of evidence collected has reference to a communication which appeared in "The Zoologist" for 1862 (p. 7996), under the heading, "Wolf Days of Ireland." On applying to the writer, Mr. Jonathan Grubb, of Sudbury, for further particulars, he obligingly replied in a letter, dated June 6, 1877, as follows:—

"I am now in my seventieth year. My father, who was born in 1767, used to tell the wolf stories to us when we were children. His mother—my grandmother—related them to him. She was born in 1731. Her maiden name was Malone; and her uncles, from whom she received her information, were the actors in the scenes described, at Ballyroggin, county Kildare. She remembered one of them, James Malone, telling her how his brother came home one night on horseback pursued by a pack of wolves, who overtook him, and continued leaping on to the hind quarters of his horse till he reached his own door, crying out, 'Oh! James, James! my horse is ate with the wolves.'"

The precise date of this occurrence cannot now be fixed; but it seems plain that wolves existed in Kildare during the first quarter of the eighteenth century, and perhaps as late as 1721.

To sum up. So far as can be now ascertained, it appears that the wolf became extinct in England during the reign of Henry VII.; that it survived in Scotland until 1743; and that

the last of these animals was killed in Ireland, according to Richardson, in 1770, or, according to Sir James Emerson Tennent, subsequently to 1766.

In the foregoing observations, no reference has been made to "were-wolves," nor has any matter been introduced touching the fabulous or superstitious aspect of the wolf's history in the British Islands. All such allusions have been purposely avoided, in order to confine the subject within reasonable limits.

Before concluding, however, we may perhaps be excused for citing so respectable an authority as Sir Thomas Browne, who, in his "Enquiries into Vulgar and Common Errors," has alluded to the popular notion that wolves cannot live in England.

In vol. iii., p. 344, of his "Works," (Wilkin's edition), he says:—"Thus because there are no wolves in England, nor have been observed for divers generations (1646), common people have proceeded into opinions, and some wise men into affirmations, that they will not live therein, although brought from other countries."

He also notices the popular belief that "a wolf first seeing a man begets a dumbness in him," a notion as old as the time of Pliny, who wrote: "*In Italia, ut creditur, luporum visus est noxius, vocemque homini, quem prius contemplatur adimere.*" In France, when anyone becomes hoarse, they say, "*Il a vu le loup.*" *

"The ground or occasional original thereof," says Sir Thomas Browne,† "was probably the amazement and sudden silence the unexpected appearance of wolves doth often put upon travellers, not by a supposed vapour or venomous emanation, but a vehement fear, which naturally produceth obmutescence, and sometimes irrecoverable silence."

A critic, adverting to this passage, has somewhat wittily remarked: "Dr. Browne did unadvisedly reckon this among his vulgar errors, for I believe he would find this no error if he were suddenly surprised by a wolf, having no means to escape or save himself!"

* Howell's Familiar Letters, vol. iv., p. 52.

† Op. cit., vol. ii., p. 422.

REVIEWS.

INDUSTRIAL CHEMISTRY.*

THIS book, although based upon Payen's *Précis de Chimie Industrielle*, has been so extensively modified and so considerably enlarged as almost to assume the form of a new work. The information contained in it has generally, although not always, been brought well up to date, and the various manufacturing processes are described with much clearness, and often with considerable detail.

The article on Sulphur includes a description of the means employed for the recovery of that body from alkali wastes by Mond's process; and that on the manufacture of sulphuric acid contains much valuable matter relative to this most important branch of our chemical industries. It is, however, to be regretted that the woodcut representing a series of sulphuric-acid chambers is somewhat antiquated, having been reproduced from a plate contained in a French edition of the original work, published nearly twenty years ago. We likewise fail to find a drawing of the ordinary pyrites kiln, now so generally in use in this country.

The production of chlorine by Weldon's process is duly described, as is also the preparation of bleaching powder in chambers; and in describing the manufacture of soda-ash, mention is made of the ammonia process, which is now being successfully carried out in this country, and which has recently taken a very extensive development on the Continent of Europe.

There are likewise valuable articles on the preservation of wood, on paper-making, soap-making, starch and sugar-making, as well as upon brewing and distillation.

The Metallurgical articles have been contributed by Dr. Paul, and are, so far as they are capable of being condensed within the limits assigned to them, generally satisfactory. Lead-smelting in the open hearth, in the reverberatory furnace, and in the blast furnace, is somewhat fully described; but at page 374, the Zeppenfeld furnace is spoken of as being still in use at Pontgibaud, whereas it has not been in operation there since 1852, and was taken down and removed early in the following year.

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* "Industrial Chemistry: Based upon a Translation of Stohmann and Engler's German Edition of Payen's 'Précis de Chimie Industrielle,'" edited throughout and supplemented with chapters on the Chemistry of the Metals, &c., by B. H. Paul, Ph.D. 8vo. London, Longmans. 1878.

Copper-smelting and the extraction of copper from burnt pyrites by the wet method, are both well epitomized; but the metallurgy of silver is not made to embrace some recent processes. The Pattinson kettles are shown with "heaters," which are now almost obsolete; and no mention is made of Luce and Rozan's steam process; while the modifications of Park's method for extracting silver from lead by the addition of metallic zinc are but briefly alluded to. These two systems have now, to a very large extent, superseded crystallization in pots and the removal of the crystals in perforated ladles. Mr. Claudet's process, by which 150,000 ozs. of silver are annually recovered from copper liquors by the addition of a soluble iodide is, however, noticed.

Dr. Paul's book, although not perfect, is in many respects superior to the original work, since not only has the chemistry of Payen been amplified and modernized, but various manufacturing processes employed in Great Britain have been supplemented to the Continental methods, chiefly given in the French and German editions. Besides this, many valuable articles have been added on the chemistry of the metals, and on the metallurgical treatment of their ores. Although, in some few cases, valuable inventions have been lost sight of, on the whole the editor has done his work very carefully, and the result is a valuable contribution to the technical literature of the country.

PHYSIOGRAPHY.*

AFTER the abundant criticism to which the latest addition to scientific terminology, represented by the word Physiography, has been subjected, Mr. Skertchly does wisely in adopting a title which is explanatory of his purpose, and which to a certain extent serves as a definition of the object he proposes to accomplish. This definition is materially aided by the quotation on the title-page which affirms that

All are but parts of one stupendous whole,

and is supplemented by a statement in the introduction, to the effect that "This volume is in one sense a manual of Physical Geography, but it differs from other works in attempting to knit the phenomena of the globe into a coherent train of reasoning. Physical Geography is too often degraded into a sort of scientific curiosity shop, in which there is a vast collection of isolated facts respecting Astronomy, Geology, Physics, Biology, and what not, without the slightest attempt at grouping them, to show how interdependent they are upon one another."

The fact is, that of late years the tendency of Science, like the impregnated ovum, has been towards fissure and constant subdivision: universal or encyclopædic knowledge has more than ever become a chimæra; and it might with more force than formerly be argued against a philosopher of the Whewell school that "Science was his forte, and Omniscience his foible."

Farseeing men, however, of Huxley's type, have realized the fact that we

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* "The Physical System of the Universe." An outline of Physiography, by Sydney B. J. Skertchly, F.G.S. Cr. 8vo., London, 1878. Daldy, Isbister & Co.

require from time to time constructive books, to balance all this Analysis; the Deductive method must be set against the Inductive; the careful collection and proper collocation of miscellaneous and disjointed observations is at least as necessary as their independent substantiation; the soldiers of the army that make war against nature must be marshalled into ranks and battalions: "*L'union fait la force.*"

Hence we have the very necessary and logical conception of the new science, Physiography. Strictly speaking it is nowise new. It was foreshadowed in the *De Rerum Natura* of Lucretius, and before that, by Aristotle and Plato; satyrized in *Tractatus de omni Scibili*, and so on; but very beautifully set before the mind in one word, Cosmos (κόσμος), by Humboldt. If Cosmos, signifying at once the Law of Order, and that concrete demonstration of this law which we behold around us in the material, perhaps even in the ultra-material, world, could be naturalized to the English language, as it has been in the more plastic and flexible German, it would serve far better than the somewhat jaunty and affected term now suggested. Physiography clashes uncomfortably with its predecessor Physiognomy, and, to the writer at least, always suggests a suspicion of photographic portraiture and *cartes de visite*, which it does not claim or deserve. But whatever be the merits or demerits of the name, the generalization is undoubtedly wanted, and will continue to be wanted from time to time as science progressively advances. Perhaps on the whole, Cosmography, now familiar to English ears, would be preferable. The essential idea involved is—an orderly review of the Systema Mundi, framed on the widest possible basis, and taking account of the latest researches in Heat, Light, and Molecular Mechanics.

On this theme, Mr. Skertchly has constructed a very agreeable and well-digested book. He states in a short preface that it owes its origin to a lecture delivered to Science teachers at the Charterhouse College, and its present publication to the fact of "the Department of Science and Art having recently become impressed with the inexpediency of teaching earth-lore as a chaotic assemblage of isolated facts."

After an introductory chapter, the writer considers in succession Matter and Motion, Light, the Sidereal and Solar systems, the Sun, the earth's internal Heat and its effects as contrasted with what is derived from external sources; leading up to what he terms "Earth sculpture." This is followed by chapters on Climate, and on the origin of Life; the work concluding with speculations upon the past and future of creation and on the finite nature of the solar system as indicated by the most recent views of the Nebular hypothesis.

The language made use of is throughout of a clear, striking and somewhat picturesque character; the main argument being elucidated by short epitomes of its essential points. As instances of lucid exposition may be named the chapters on the Precession of the Equinoxes, and on the newly discovered Repulsion from Radiation as explaining the behaviour of cometary envelopes. The conclusion of the work deserves quotation:—

"All our knowledge tends to strengthen belief in the Nebular Hypothesis under some form or another. But it may be asked, if this be true of our system, are we to stop there? The stars are suns and move in systems.

Our sun is a member of one of these. Was that grander scheme evolved from a yet grander Nebula? Who can tell? If so, how infinitely more simple would appear the unity of creation!"

W. H. STONE.

THE MOON.*

MR. PROCTOR'S works have so recently received attention in these pages, that it is hardly necessary to do more now than to record the appearance, in a second edition, of one of his best books. The present, it seems, however, is not merely a reprint, nor even an amplification of the former issue, but rather a subdivision for the convenience of non-mathematical readers.

In a short preface, Mr. Proctor says, "I have found reason to believe that portions of the original work were too difficult for the general reader. I have, therefore, removed from the present edition matter relating to details of the lunar theory (leaving the general account of the moon's motions) and also the more difficult parts of Chapter III. These will be reprinted in another volume. The last chapter on the moon's physical condition has been considerably enlarged."

W. H. STONE.

AMERICAN STATE PUBLICATIONS.

We have once more to call attention to a long series of valuable publications issued either by the Central Government of the United States, or by individual states; and we do this with a certain feeling of sadness, as we have heard a rumour that perhaps the most important of the sources to which we are indebted for this seemingly perennial spring of scientific literature, namely, the "Geological and Geographical Survey of the Territories," so ably conducted by Dr. F. V. Hayden, is about to be, if not suppressed, at least considerably shorn of its means of useful work. It is true that the liberality with which the publications of this survey have been scattered over the face of the earth might easily be construed into unnecessary profusion by legislators of economical tendencies, and it would be easy to show that many of the works have thus fallen into the hands of those who did not appreciate them, for he would need to be indeed an "all-round man" who should be equally interested by all the volumes produced; but on the other hand, we may be sure that many of the books which thus apparently go astray in the first instance, eventually find their way to the shelves of those who feel a lively interest in their contents, and thus justify the liberality with which they are distributed. On the other hand, the work done by this Survey (of the quality of which the "Atlas of Colorado" noticed below is a brilliant illustration) is so exceedingly good, and the importance of accurate information upon the natural phenomena of a new country like these western territories is so great, that we cannot imagine any valid objection being raised to the continuance of its labours. We must, therefore, express

* "The Moon, her Motions, Aspect, Scenery, and Physical Condition," by Richard A. Proctor. Second Edition. London: crown 8vo. pp. 314. Longmans.

a hope that, even if it be found desirable to restrict somewhat the number of gratuitous recipients of these publications, no check will be put upon the activity of Dr. Hayden and his staff of assistants, and that we may still from time to time be able to announce the results of their researches.

How far one of the works which has reached us is to be regarded as confirmatory of the rumour above referred to we cannot tell, but the conclusion of Dr. Hayden's prefatory note sounds very like it. This book* is a quarto volume of 26 beautifully executed plates, containing numerous figures of fossil plants from the Cretaceous and Tertiary strata of the Western Territories, which, as Dr. Hayden tells us, have been engraved and printed for a period of seven years, awaiting the final report of Dr. J. S. Newberry, which was intended to form vol. VIII. of the quarto series of Survey Reports. The greater part of these plants were described as long ago as 1867, in a paper read before the Lyceum of Natural History of New York, and published by that institution in its "Annals" in 1868; so that, should the text never appear, "these plates will not be entirely lost to science," but will serve as illustrations to the descriptions published ten years ago. The names and references have been appended to the figures by Professor Lesquereux.

The splendid atlas of the Colorado Region,† lately published, is perhaps the grandest, certainly the most striking monument of the labours of the Survey over which Dr. Hayden so worthily presides. It consists of twenty large sheets, and illustrates the geological, topographical and other natural characters of an extensive district, embracing the whole of the Colorado territory and the adjacent portions of Utah, Arizona and New Mexico. Four of the maps are on a scale of 12 miles to the inch, and show the triangulation of the district, its drainage, its economic peculiarities and its general geology. In the third of these maps the arable and pasture lands, the forest and desert lands, and the mining districts are indicated by means of colours and symbols. Six geological maps, on a scale of four miles to the inch, show the geological structure of the country in more detail than the smaller one above referred to; and these same sheets, without the colours, serve to indicate the topography and orography of this interesting region, the contour lines (which also appear in the geological maps) being placed to show approximately differences of level of 200 feet. Two sheets of sections, and two of panoramic views complete the atlas, the execution of which is throughout admirable. In fact, with this atlas in his hand the student may gain a more perfect notion of the distant and wonderful Colorado region than he can readily obtain of localities much more generally known and much nearer home; and the highest honour is due, not only to Dr. Hayden and his staff, but also to the American Government authorities, under whose auspices so magnificent a work has been accomplished.

Of the "Bulletin"‡ two parts have been issued during the present year, and these, as usual, present a varied and interesting series of articles. Zoo-

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* "Illustrations of Cretaceous and Tertiary Plants of the Western Territories of the United States."—4to. Washington, Government Printing Office, 1878.

† "Geological and Geographical Atlas of Colorado and portions of adjacent Territories," by F. W. Hayden, U.S. Geologist in charge.—Large folio, 1877.

‡ "Bulletin of the United States Geological and Geographical Survey of the Territories," vol. IV., Nos. 2 and 3, 8vo. Washington, 1878.

logical papers occupy the greater part of these two numbers, and the first of them is a most important contribution from the pen of Dr. J. A. Allen on "The Geographical Distribution of the Mammalia," in which he upholds his opinion, originally put forward in 1871, that life is distributed over the earth's surface "in circumpolar zones, which conform with the climatic zones, though not always with the parallels of the geographer." It will be seen that Dr. Allen is diametrically opposed in principle to Dr. Sclater and Mr. Wallace, whose opinions he criticizes pretty freely. His proposed primary divisions are as follows:—

I. An Arctic, or Circumpolar.

II. A North Temperate, divided into two regions and eight provinces.

III. An American Tropical, with three regions.

IV. An Indo-African, with two regions and five provinces.

V. A South American Temperate, with two provinces.

VI. An Australian, with three regions, one of them divided into two provinces.

VII. A Lemurian.

VIII. An Antarctic or South Circumpolar.

The ichthyologist will find in these two numbers some valuable notes by Dr. D. S. Jordan on a collection of fishes from the Rio Grande, and a complete catalogue of the freshwater fishes of North America by the same author.

Of entomological papers there are several, the most important of which is Dr. Le Conte's article on "The Coleoptera of the Alpine Region of the Rocky Mountains." In this paper the author remarks briefly upon the conditions which have governed the distribution of these Alpine beetles, and describes many new species belonging to various families, gives a list of coleoptera collected in the Rocky Mountains at elevations of 6,000 feet and upwards, and characterizes in an Appendix the known North American species of *Nebria*. Dr. Cyrus Thomas has some notes on orthoptera collected by Dr. Coues in Dakota and Montana, with remarks on the natural history of *Caloptenus spretus*, one of the most destructive of the North American locusts; followed by papers on the rhynchota and lepidoptera, collected at the same time by Dr. Coues, by Dr. Uhler, and Mr. W. H. Edwards. Mr. A. R. Grote contributes the first of a series of papers on North American pyralidæ, which promises to be of great value. Dr. Elliott Coues himself gives a long account of the birds observed by him in Montana and Dakota in 1873–74, in which the ornithologist will find many valuable notes on the habits of birds.

The palæontological papers in these two numbers are not numerous. Prof. Cope furnishes descriptions of new vertebrates from the Upper Tertiary and Dakota formations, chiefly mammalia and chelonia, but including also some other reptiles and species of *Graculus*, *Anser*, and *Cygnus*. Among the mammals we note a new pliocene *Auchenia* and a new genus (*Ticholeptus*) of Oreodontidæ from the Miocene of Montana. Mr. Scudder gives a preliminary notice of some of the fossil insects which he has lately obtained in such astonishing abundance from the Tertiaries of Colorado and Wyoming, including a remarkably perfect fossil butterfly, which still shows the pattern of its markings, and which he names *Prodryas persephone*, a dipterous fly

(*Palembolus florigerus*) belonging to the family Nemestrinidæ, a Longicorn beetle (*Parolamia rudis*) belonging to a group not now represented in North America, two species of homoptera (*Petrolystra gigantea* and *heros*), which he regards as gigantic allies of our common froghoppers, a great locustid (*Lithymnetes guttatus*), a slender dragon fly (*Dysagrion fredericii*), fossil masses of the eggs of a *Corydalites*, and a supposed panorpid (*Holcorpa maculosa*). Mr. Scudder also mentions the discovery by Dr. A. C. Peale, near the Green River, of fossil cases of caddis-worms, similar to those of the so-called indusial limestone of the Auvergne. The fossil bird of Florissant (see p. 321) is described and figured by Dr. J. A. Allen.

Dr. C. A. White describes some new species of invertebrate fossils from the Laramie group, and discusses the distribution of the fossils in that group, which includes the beds between the cretaceous Fox Hills group and the tertiary Wahsatch group. Prof. Calvin notices as a new member of the Devonian some dark shales discovered below the limestones of that formation at Independence in Iowa, and describes five new species of brachiopods which he regards as characteristic of this deposit. The last paper is a list of the minerals of Nevada by Dr. W. J. Hoffman.

An unpretending but exceedingly useful little book, the preparation of which must have cost its authors an immense amount of labour, is "The Bibliography of North American Invertebrate Palæontology,"* just issued as No. 10 of the "Miscellaneous Publications" of the Survey of the Territories. It contains a complete list, with references, of all works and papers relating to the invertebrate fossils of North America, from the West Indies to Greenland; and the value of the book is enhanced by the brief indications of the general nature of the contents of the articles which are generally appended to them. This catalogue is divided into two parts, the first embracing works published in the United States, the second those which have appeared in British America and elsewhere. The former is prepared by Dr. C. A. White, the latter by our countryman, Prof. H. Alleyne Nicholson. The best thanks of palæontologists are due to these gentlemen for performing a task so thankless in itself.

While Dr. Hayden's operations are carried on under the auspices of the Department of the Interior, the United States Secretary of War has his own survey, namely the geographical survey west of the one hundredth meridian, under the charge of Lieut. G. M. Wheeler, the publications of which are almost as voluminous and varied as those of the older staff. The last published report of this survey is by Prof. E. D. Cope, on "The Extinct Vertebrata obtained in New Mexico in 1874,"† a quarto volume of nearly 380 pages, illustrated with 83 plates. In this valuable contribution to the palæontology of the western United States, Prof. Cope not only describes

* "Bibliography of North American Invertebrate Palæontology; Miscellaneous Publications, No. 10," by C. A. White, M.D., and H. Alleyne Nicholson, M.D., D.Sc. 8vo, Washington, 1878.

† "Report of the United States Geographical Surveys West of the One Hundredth Meridian, in charge of First Lieut. G. M. Wheeler, under the direction of Brig.-Gen. A. A. Humphreys, Chief of Engineers, U.S. Army," part II., vol. IV., Palæontology, 4to. Washington, Government Printing Office, 1877.

a great number of interesting fossil vertebrates, but also discusses the geological structure of the western slope of the Rocky Mountains and the plateau to the west of them in north-western New Mexico, in which he identifies probably Triassic strata of freshwater origin, and Cretaceous, Eocene, Upper Miocene, and Postpliocene deposits. The mesozoic fossils are very few, consisting only of a cretaceous fish apparently allied to *Mugil*, and a few triassic (?) *Crocodilia*, *Dinosauria*, and *Sauropterygia*. Besides these, Prof. Cope describes some fossil dinosaurian bones under the name of *Dystrophæus viæmalæ*, obtained from the supposed triassic rocks of south-eastern Utah. The Eocene fossils, which are from the Wahsatch formation, are much more numerous, the total number of species here described being 87, of which 54 are mammals, 24 reptiles, 8 fishes, and 1 a bird. The reptiles include species of crocodiles, lacertilia, and testudinata, the last order making up two-thirds of the whole. Among the mammalia, the carnivora, quadrumana, proboscidea, and ruminantia are wanting, and no remains of edentata or chiroptera have been found. From the consideration of the fossils, Prof. Cope is inclined to correlate the Wahsatch formation with the Suessonian of Europe (Lower Eocene). In connection with this Prof. Cope has some remarks on the origin of the various groups of mammalia by descent, accompanied by a new version of a table published by him six years ago. The Loup Fork formation, which Prof. Cope correlates with the European Upper Miocene, has furnished him with 34 species of vertebrata in the marls of Santa Fé in New Mexico, two of them being tortoises, three birds, and twenty-nine mammals. From Prof. Cope's point of view these mammalia exhibit a decided advance on those of the Wahsatch group, as they include a proboscidean (*Mastodon productus*, allied to *angustidens*), five carnivora (four of them dogs or wolves), and eleven Artiodactyla, giving a decided preponderance to the gyrencephalous forms. All these fossils are beautifully figured in the numerous plates, which, as we have already stated, accompany the volume, and place visibly before us the forms and characters of the magnificent series of remains of vertebrate animals which it has been the author's good fortune to work out and describe.

Of State Geological Survey Publications, we have received a volume of the "Geology of Wisconsin,"* which, although professing on its title page to be the second volume, is in reality the first issued. The first volume, we are told by the chief geologist, Mr. T. C. Chamberlin, will contain "general conclusions that can only be arrived at after the completion of field work, and its appearance must be delayed until that work is accomplished." The State of Wisconsin occupies a large extent of ground between the western shore of Lake Michigan and the Mississippi river, and the work before us includes the details of the topographical and geological structure of all but its north-western portion. It is divided into three sections: the first, relating to the eastern parts, is by the Chief Geologist himself; the second, describing the central regions, is by Mr. R. D. Irving; whilst Mr. Moses Strong gives an account of the lead region, a comparatively small district in

* "Geology of Wisconsin, Survey of 1873-1877." Vol. II. Accompanied by an Atlas of maps. Published under the direction of the Chief Geologist, by the Commissioners of Public Printing. 8vo., 1877.

the south-western corner of the State. All these gentlemen seem to have done their work in a most conscientious manner, and although probably many details still remain to be investigated, the result of their labours furnishes a very good idea of the geological phenomena of this region. Its structure, indeed, is tolerably simple. In the northern part of the State there is an immense mass of crystalline rocks, which are for the present referred to the Laurentian. These are partially overlain by quartzites, slates, &c., identified with the Huronian, and like it containing considerable quantities of iron ores; and both these archæan formations make their appearance now and then through the more recent rocks of the other parts of the state. Even these newer formations are all of very ancient date. In central Wisconsin no rocks are met with younger than the Lower Silurian Trenton and Galena limestones; whilst the eastern division contains the Cincinnati, Niagara, and Lower Helderberg groups, and also exhibits a small development of the Hamilton group of the Devonian. Above these Palæozoic rocks there is nothing except the Drift and the Champlain deposits. Mr. C. W. Wright appends to the second section descriptions of the microscopic characters of a great number of the crystalline rocks. Besides describing the geology of the country, each author furnishes details of the topographical character and hydrology, and of the soils and vegetation of the region surveyed by him, so that the physical geography of the country is pretty well worked out, and the whole is admirably illustrated by the magnificent atlas of 14 large coloured maps and sections which accompanies the volume. The book itself is also profusely illustrated with plates and woodcuts.

Not to be behindhand with its neighbour on the other side of the Mississippi, the State of Minnesota has also its survey, directed by Professor N. H. Winchell, which is placed under the care of the Board of Regents of the University of Minneapolis. It has the title of the Geological and Natural History Survey of Minnesota, and its fifth Annual Report* has just reached us. This includes reports on the geology and surface features of Houston and Hennepin counties, in which the phenomena presented by the drifts are especially dwelt upon, and the question of the time occupied in the recession of the Falls of St. Anthony, which was briefly referred to in our last number (p. 319), is treated in considerable detail. The botanist, Dr. A. E. Johnson, contributes a list of the known fungi of Minnesota, which is of interest to the student of the geographical distribution of those plants; and the Entomologist furnishes a long report on the evil-doings of that scourge of the American agriculturist, the Rocky Mountain locust. The other contributions are chiefly of local interest, except the description of a new species of *Cyclops* (*C. longicornis*) by Mr. C. L. Herrick. The illustrations consist of a few woodcuts and several maps, some of which are coloured.

The report of the United States Commission of Fish and Fisheries for 1875-76†, which has recently appeared, relates more specially than some

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* "The Geological and Natural History Survey of Minnesota. The fifth annual report for the year 1876." 8vo. St. Paul, Pioneer Press Company, 1877.

† "U.S. Commission of Fish and Fisheries." Part IV. Report of the Commission for 1875-76. 8vo. Washington Government Printing Office, 1878.

former reports to the question of the falling off in the supply of food fishes and the means to be adopted for restoring it to a satisfactory condition; in an appendix exceedingly interesting details are given with respect to the vigorous attempts which have been, and are still being made, to restock the fresh waters of the United States with those valuable species of fishes, especially salmonidæ, which formerly swarmed in them, but have given way before the rapid increase of population. But the greater part (nearly 800 pages) of the stout octavo volume before us is occupied by a most elaborate report on the history of the American whale fishery, from its commencement, in the year 1600, to the present day, illustrated with six plates, giving outline figures of different species of whales and the instruments used in their capture, and accompanied by a tabular list of all the voyages that have been made by American whalers and their results. As a statistical record this will be found of the highest value.

URE'S DICTIONARY OF ARTS, MINES, AND MANUFACTURES: SUPPLEMENT.*

ON the completion of the third volume of this Dictionary, in 1873, it was found that several of the articles contained in the earlier portions of the work required amplification, in consequence of the rapid advances which had taken place in the various applications of science. In order, therefore, to bring up the information to the present date, as well as to record the general progress of mining and metallurgical invention, the present supplement has been written. In carrying out this work Mr. Hunt has secured the assistance of gentlemen practically acquainted with the various subjects on which they have written, and has also been furnished with information by various correspondents possessing special information upon the subject of arts, mines, and manufactures. Obligations are also freely acknowledged to such journals as the "Engineer," "Engineering," the "Chemical News," &c., as well as the "Transactions of the American Institute of Mining Engineering," the "Journal of the Franklin Institute," and the "Mining Journal of New York."

Among the more lengthy communications is a valuable article on the "Manufacture of Boots and Shoes by Machinery," by Mr. R. Meade; this extends over about thirty-five pages, and is illustrated by numerous woodcuts of the most modern machinery and appliances employed in that branch of manufacturing industry. From the statistics accompanying this article it appears that our largest customer for boots and shoes, of all kinds, is Australia, to which colony, in 1875, no less than 185,688 dozen pairs were exported; while the next largest amount, namely, 94,153 dozen pairs, was sent to British possessions in South Africa.

Mr. John Darlington contributes papers upon "Ore Dressing" and "Rock-boring Machinery," in which he has collected much valuable information upon a subject to which he has devoted considerable attention. Mr. G. A. Cowper's articles upon "Furnaces and Hot-blast Stoves" are sound and

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* "Ure's Dictionary of Arts and Manufactures." By Robert Hunt, F.R.S., &c. Vol. IV.—Supplement. 8vo. London, Longmans, 1878.

practical; and the "Diamond Mines of South Africa" are well described by Mr. Francis Oats, who for some years occupied the position of Provincial Mining Engineer at Kimberley. Mr. Robert Oxland, of Plymouth, furnishes a description of his rotating calciner for sulphurous and arsenical ores; and Mr. Thomas Andrews, of Edinburgh, gives an article upon the "Mineral Oils used for Lighting Purposes."

The shorter notices have been carefully prepared, and supply information upon such recent discoveries as the telephone and phonograph. The Supplement to "Ure's Dictionary" is in every way worthy of the original work, and will form a valuable addition to the library of the miner, manufacturer, and metallurgist.

THE SIGHT.*

DR. ANGELL'S little book on "The Sight" is intended by its author to diffuse generally a knowledge of the phenomena of vision, and to furnish the public with reliable information as to the means to be adopted for the preservation of the faculty of sight. In face of the increasing prevalence of weak sight among us, it must be confessed that this object is a most important one, and we can only express a hope (not a very sanguine one, however) that it may satisfy the author's aspirations. If it fails, it will not be his fault, as his book is certainly one of the best adapted to its purpose that we have seen. The use of technical language is avoided as much as possible.

Dr. Angell furnishes his readers with a short description of the structure of the eye, so as to explain how we see, and what are the causes of defective vision. He then proceeds to the discussion of the various kinds of defective vision, their causes and remedies, or at all events the best modes of ameliorating those defects of vision which steal upon us in consequence of increasing years or failure of the eye at an earlier age. His remarks upon near sight in children and young people and its causes are of great importance.

There are one or two points to which we may refer.—At page 42 the author says that "twenty-five men in every hundred are more or less colour-blind: they cannot distinguish red from green." This ratio is much higher than is generally admitted, though perhaps very slight degrees of colour-blindness may occur in such proportions. On page 29, line 22, the eye in near sight is said to be "adjusted or accommodated" for a point nearer than the object looked at; the use of these two terms is unfortunate, as they are technically used to signify the change in the refractive state of the eye brought about by muscular action. The refractive state of the eyeball in near sight is dependent on the construction of its media, and would continue in a dead eye if this preserved its shape and clearness. The true sense of accommodation is given by the author at page 12, but it might easily escape the memory of a reader interested only in near sight. These and one or two other small matters which might be cavilled at are, however, of little consequence, and we may recommend Dr. Angell's book as a very clear and comprehensive treatise on the management of the eyes. It is freely illustrated.

* "The Sight and How to Preserve It."—By Henry C. Angell, M.D., Professor of Ophthalmology at Boston University, sm. 8vo., London: Hardwicke and Bogue, 1878.

TELEGRAPHY.*

THIS is essentially a working book, and its value in this capacity may be appreciated from the fact that it is now in its seventh edition.

The telegraphs in Great Britain and Ireland having now passed into the hands of the State, a sketch of the history of the system is given by way of introduction.

This notes the joint patents of Cooke and Wheatstone in 1837, which first demonstrated the practicability of the plan on an experimental circuit between Euston and Camden Town, followed in the next year by an actual working telegraph between Paddington and West Drayton. These patents were purchased by the Electric and International Company, incorporated by Act of Parliament in 1846, but for several years proved to be pecuniarily unprofitable.

At first the double needle was used for the more important circuits, the single for the less important.

The former was superseded by Bain's chemical recorder, and this in turn gave way to Morse's ink-writer, the single needle holding its place in consequence of the ease with which it is kept in order.

The magnetic instrument was found to be laborious in manipulation. Bright's bell instrument leaves the hands free for writing the message. The United Kingdom Company used the Morse and Hughes's systems only.

The first six chapters, occupying 113 pages, are devoted to the laws of electricity generally; the seventh and eighth, amounting to 132 pages, explain construction and modes of testing. Part IX. is concerned with apparatus, relays, duplex working and Hughes's instrument; Part. X. with submarine telegraphy; Part XI. with automatic telegraphs which record their signals; the twelfth and last section with recent inventions, the telephone and the quadruplex system.

Valuable tables of logarithms, measures, constants, guages and coefficients conclude a very practical work. The text is illustrated with abundant figures and diagrams; and simple numerical examples are introduced freely wherever they are needed.

W. H. STONE.

PHOTOGRAPHY.†

ANYTHING Captain Abney may publish on the subject of Photography is sure to be of value. The present work is stated to be supplemented by that on "Instruction in Photography," by the same author; it having been found impossible to compress the necessary matter into a single volume.

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* "A Handbook of Practical Telegraphy," by R. S. Culley. Seventh Edition, revised and enlarged. London: 8vo. pp. 468. Longmans, 1878.

† "A Treatise on Photography," by W. De Wiveleslie Abney, Captain R.E., F.R.S., &c.: sm. 8vo. pp. 326, London: Longmans, 1878. Text-books of Science.

Hence this is devoted less to what may be called commercial applications of the art, and more to the theoretical aspect of the subject.

It commences with a historical sketch of the early experiments of Wedgwood, Niepcé, Daguerre, and Talbot, occupying five pages, followed by four pages of experiments on Light. These bear traces of haste, due probably to the necessity for great condensation. For instance, silver chloride is described as luna corn*ua*, light as a *fluid*, and parallel rays in the dark chamber are made, by the illustration on page 7, to pass with unaltered parallelism through a condensing lens and a prism, and still uninverted, to give a real image on a screen.

With Chapter III., containing the theory of sensitive compounds, we reach more congenial ground, and in the 36 chapters which follow, it is remarkable how much practical information has been condensed into a little over three hundred pages. Indeed it is not possible with limited space to do more than enumerate the chief topics introduced. Sensitive silver, iron, and chromium salts; asphaltum, dyes, chlorine and hydrogen, sulphur and antimoniuretted hydrogen as influenced by light, form the bulk of the fourth; the daguerreotype, collodion, the wet process, development, intensifying and fixing, each furnishing successive chapters. An account of wet-plate manipulation, and its defects, both in negative and positive pictures, is followed by dry plate, gum, gallic, and albumen-beer processes. Emulsion processes, the gelatino-bromide and calotype processes, are each separately described. Silver printing and its manipulation is adverted to at some length; as is printing with iron, uranium and chromium salts. Photo-lithography, photo-engraving and photo-collotype bring to an end the list of methods. The twenty-ninth section describes the lens, and the thirtieth the camera, tents, dark rooms, and other apparatus. It may be noted here that perhaps the laws of refraction, dispersion, aberration, conjugate foci, and some other common places of optics, in a case where space is evidently precious, might well have been left to rudimentary text-books on that subject. Chapter thirty-one on the picture, the choice of a point of view, grouping, and composition, is of remarkable value, illustrated as it is by some charming little woodcuts. A stranded boat by Manners Gordon, and a view on the Thames by Woodbury, positively light up their respective pages. There is a return, in the three following chapters, on actinometry, photo-spectroscopy, and thermal photography to purely theoretical considerations; and in those on solar, stellar, and celestial work we have a good *résumé* of the astronomical value of this fascinating art. Micro-photography, and some miscellaneous applications, such as that to meteorological registration, to military service, and to the identification of criminals, conclude the work.

In another edition, the feeble woodcut of temporary photo-spectrum apparatus at page 265, the description and drawings of Mr. Browning's automatic arrangement, and of Stoney's Heliostat, might well be omitted in favour of more specifically photographic apparatus. But there is much valuable material in the book.

W. H. Stone.

SPECTRUM ANALYSIS.*

THE demand for a reprint of this work within a few months of its first issue is, of itself, evidence of the interest which it has deservedly excited. Nor is there any difficulty in explaining the fact, since it distinctly occupies a gap, and fills up a lacuna left by such excellent treatises as those of Roscoe and Schellen. It does not even clash with the same author's other volume on working with the Spectroscope, published by Macmillan. The discovery of spectrum analysis has indeed opened such a vast and new field to human observation, that there is abundant room, nay, imperative necessity, for manuals and treatises of very diverse nature. This is well described in its opening sentence: "The work of the true man of science," says the author, "is a perpetual striving after a better and closer knowledge of the planet on which his lot is cast, and of the Universe in the vastness of which that planet is lost. The only way of doing this effectually, is to proceed as gradually, and therefore as surely, as possible, along the dim untrodden ground lying beyond the known."

Whereas former works have been dogmatic, descriptive, and educational, this rather aims at being tentative, inductive, and experimental.

As the whole subject is to many readers new and unfamiliar, the first forty-six pages have been devoted to a *précis* of the great generalization of waves and wave motion on which modern physics rests. These we may be excused for passing over in a brief notice like the present. The second chapter deals with modes of demonstration and laboratory work. Here we at once find matter of specific interest.

Attention is called to the difference between the ordinary spectroscope and one that has a lens before the slit. If light be allowed to enter indiscriminately as it emanates from a complex source, in each part of the spectrum we get an "integration" of the light of the same wave-length proceeding from all the different light-waves. But if by means of a lens we form an image of the source, so that each particular part shall be impressed in its proper place on the slit, then in the spectrum the different kinds of light will be sorted out, and if there be any variety in the phenomena which these different sources of light present, they will be all clearly shown in the spectrum or its photograph. We turn the spectroscope from an "Integrator" into an "Analyser." The slit for a vertical image of a candle, for instance, requires to be placed horizontally. We then get three perfectly distinct spectra indicating the coexistence of three light sources, each with its proper spectrum, in the light of a common candle.

This mode of observation, originally proposed in 1866 by the author, for the examination of minute portions of the Sun and his surrounding atmosphere, has been adopted in most of the work subsequently detailed. In a photograph of a *horizontal* electric arc, thrown by means of a lens on a vertical slit, it is shown that the spectrum consists of a large number of lines of different lengths in the "core" or centre of the arc, all of which die

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* "Studies on Spectrum Analysis." By J. Norman Lockyer, F.R.S. Cr. 8vo. pp. 258. Kegan Paul & Co. International Scientific Series. Second edition.

out gradually, until that of the part farthest from the centre consists of one line.

In thus employing sodium, bright lines are obtained of different lengths, without any continuous spectrum; and as the distance between the poles is increased, one line is seen alone and much brighter than the rest, the yellow line remaining after the others have disappeared. "The spectroscope, thus armed, is in fact a new instrument."

Radiation and absorption phenomena are next described, and some charming modes of demonstration, which space alone excludes here, are described.

The third chapter deals with spectrum photography. Its history is given in Mr. Lockyer's brilliant style, and will well repay reading, especially his quaint description of Mr. Rutherford's telescope "through which it is impossible to see anything, but through which the minutest star can be photographed with the most perfect sharpness."

He then describes his own arrangements, especially that of the fivefold slit, and the various means of comparing spectra. Here, as in the frontispiece, and in four other cases, we find a striking whole page illustration, the reproduction of a photograph, the method of obtaining which does not appear to be given, but which seems to be lithographed in a grey pigment on black paper.

Chapter IV. considers Atoms and Molecules spectroscopically. After a recapitulation of modern views as to the molecular condition of matter, twenty-one propositions are in turn discussed, many of which are of the highest importance. A few of these may be noted: (5.) The spectra of both elementary and compound bodies vary with varying degrees of heat. (7.) There is spectroscopic evidence that matter is continually broken up as the temperature rises. Five stages of this process are given: α. Line spectra. β. Fluted spectra. γ. Continuous absorption at the blue end. δ. The same at the red end. ϵ. "Unique" (Complete?) continuous absorption. (12.) Particles absorb light of the same wave-length, and greater amplitude. (20.) Some vibrations are very closely connected with others, as evidenced by repetition of similar groups of lines in different parts of the spectrum. For example,—in sodium the longest line, D, is double. So are all the lines. In magnesium the longest line is triple. So is that in the violet. Long and short lines are treated next, and the spectra of salts follow. In the section on dissociation, the chemist, in the separation of elementary bodies, is shown to act mainly by means of vibrations. "He finds the world composed of molecules in millionfold complexity, combination, and size, and he acts upon these molecules by vibrations. For gross molecules he finds in heat most that he wants; but when the molecules are more delicate, then electricity is called in." With the aid of the spectroscope, additional help is afforded in the study, both of the quantity and quality of dissociation, and it is found to afford precious suggestions regarding change of molecular structure. The conclusions come to are: (1.) That a compound body has as definite a spectrum as a simple one; but while the spectrum of the simple metal consists of lines, the number and thickness of some of which increase with molecular approach, the spectrum of the compound consists in the main of channelled spaces and bands, which increase in like manner. Both spectra have their long and short lines. (2.) That the heat required to act on a compound so as to

render it visible, dissociates the compound according to its volatility; the number of true metallic lines which thus appear is a measure of the dissociation; and as the metal lines increase in number the compound bands thin out. This principle is applied to the dissociation of the so-called elements, especially calcium. Evidence in favour of this is derived first from a series of five spectra of this substance at different temperatures, and secondly, from the remarkable photograph of the spectrum of *a* Lyræ obtained by Mr. Huggins, in which only *one* of the solar H lines is represented.

If the elements be really compounds, these must have been formed at very high temperature, to which, by theory, there is no superior limit. If calcium be a distinct entity, by working at it alone, we shall never know "whether temperature produces a simpler form of the same thing, or whether we actually break it up into X + Y, because neither X nor Y will ever vary. If it be a product of lower temperature, then in stars hot enough to enable its constituents to exist uncompounded, we may expect them to vary in quantity, and *a* Lyræ would thus represent an extreme case."

An attempt at Quantitative Analysis by means of the spectrum is the next topic introduced, an idea first suggested by Janssen, and demonstrated by Frankland, who showed that the spectrum of hydrogen at a pressure of 20 atmospheres is as continuous as that from burning coal. In the solar spectrum the line in the green widens toward the Sun, indicating an approximation to a continuous spectrum; at 20 atmospheres it would be continuous. Increase of pressure is therefore the determining power. If so, the same lines should become thinner with decreased pressure, and thicken with its increase. This they do. There is, therefore, "individuality" in the spectral lines. Experiments by mixture were made to carry out this idea. Alloys of silver and gold obtained from the Royal Mint were also employed for the purpose, the results being represented by curves, the co-ordinates of which showed the composition of the alloys as determined by the ordinary method of assay, compared with the varying points of equal brightness measured by the micrometer of the observing telescope fitted with movable horizontal wires. The parting assay determination, when revised, was almost identical with that of the spectroscope.

A chapter on coincidences of spectral lines, and the elimination of those due to impurities, leads to the tenth and last on the elements present in the Sun. Kirchhoff and Angström's work is reviewed; it is shown that when the spectra of metallic vapours reversed in the solar spectrum are mapped by the new method, the reversed lines are invariably those which are longest in the spectrum. It was thus at once seen that zinc, aluminium, and, possibly, strontium must be added to the table of solar elements.

As a preliminary, two lists were formed, one containing solar, the other, non-solar elements. The former were found, as a rule, to form stable oxygen compounds, and others of this group were then sought for. Cadmium, lead, copper, cerium, and uranium were provisionally added to Thalén's last list.

As the final result of laborious work, three tables are given: the first, of elements whose presence in the Sun's reversing layer has been confirmed, amounting to 22; the second, of those whose presence is probable, in number 10; and the third, of elements absent from the Sun, according to our present knowledge. These are carbon, silicium, and thallium, chlorine, bromine, and iodine.

FUNGI.*

It is impossible to express too strongly the obligations under which students of natural history lie to those of their number who will undertake the labour of bringing together, into one handy book, references to all the scattered descriptions and figures published upon some group of animals or plants. This indebtedness is very great even when the compilers limit themselves to the preparation of a mere catalogue; but when, as in the case of Messrs. Cooke & Quelet's "Key to the European Hymenomycetous Fungi," brief characters of the species are added and the whole mass of information is condensed into a volume small enough to be conveniently carried in the pocket, it must be confessed that the authors have conferred upon their brother naturalists a boon of the very highest value. The "Clavis Hymenomycetum Europæorum," which is written throughout in Latin, contains short characters of nearly 3,000 species of agarics, boleti, and their allies, and will stand the travelling fungologist in good stead in the determination of unknown plants of this important order that he may meet with. The reputation of the writers is a sufficient guarantee of the quality of their work.

MILLER'S ELEMENTS OF CHEMISTRY. SEVENTH EDITION.†

MILLER'S "Elements of Chemistry" has long held a distinguished position among chemical text-books, and there can be no doubt that the present edition, which has been ably edited by Mr. Groves, who has contributed much additional matter, will be equally appreciated by chemical students.

Commencing with elements which form the least complex compounds, and gradually passing onwards to those forming more numerous and complicated substances, the order in which the non-metallic elements and their compounds are described is the same in this edition as in the last. As a standard of reference for the atomic weights of the elements and the densities of gases, as well as for a measure of the atomicity of the other elements, hydrogen occupies the first place, as being the type of electro-positive substances. This is followed by chlorine, as an example of an electro-negative element of remarkable chemical activity, and which forms a large and important series of combinations. Oxygen is then brought before the attention of the student as one of the most important elements, and one which, on that account, is even now sometimes placed first in order, as was the case in the earlier editions of this work. The compounds of oxygen with hydrogen and chlorine are subsequently described; then follow boron, a triad; carbon, a tetrad; nitrogen, a pentad; sulphur, a hexad; together with the compounds they severally produce with the elements previously studied. The other non-

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* "Clavis Synoptica Hymenomycetum Europæorum, conjunctis studiis scripserunt M. C. Cooke, M.A., F.L.S., et L. Quelet, M.D., O.A., Inst. et Sorb. Laur." Sm. 8vo. London, Hardwicke & Bogue, 1878.

† "Elements of Chemistry: Theoretical and Practical." By William Allen Miller, M.D., LL.D., late Professor of Chemistry in King's College, London. Revised by Charles E. Groves, Fellow of the Chemical Societies of London, Paris, and Berlin, &c. Part II., Inorganic Chemistry. Seventh Edition, with Additions. 8vo. London, Longmans, 1878.

metals are described in an order consistent with the arrangement of the more typical elements.

The formulæ used are substantially those employed in the last edition, and wherever the constitutional formulæ suggested by Dr. Frankland are introduced, they are enclosed within square brackets to indicate that they are an interpolation in the original work. The whole bears evidence of careful revision, and many additions, particularly in the portions devoted to the non-metallic elements, have been made. The metallurgy of all the more important metals is described with sufficient detail to afford general ideas of the various processes employed; but in the case of iron, the production of which gives rise to one of our most important technical industries, its metallurgy is given with considerable detail. Sections are introduced on the recently discovered metals, gallium and davyum; a copious index has been supplied, and every care appears to have been taken, not only to insure great accuracy, but also to render the information furnished readily available.

This work can be equally recommended to the beginner and to the advanced student of chemistry, since whilst it leads the former over a judiciously traced route to an acquaintance with that science, it at the same time affords the latter a well-arranged and reliable book of reference.

SCIENTIFIC SUMMARY.

ASTRONOMY.

The Eclipse of July 29.—Undoubtedly the observations made during the recent eclipse form the chief feature of the astronomy of the last quarter. It was thought by many that little of importance would be learned. We are told, indeed, that one distinguished American astronomer declined to visit the shadow-track, on the ground that eclipses were "played out." But the observations were, in reality, of extreme interest and importance.

In the first place the extension of the corona outwards into the zodiacal light has at last been demonstrated. Few who have studied eclipse phenomena carefully have doubted that the outer corona belongs to the core of the zodiacal light, but this could not be said to be demonstrated observationally until the zodiacal light had actually been seen during total eclipses. Hitherto observers had failed to effect this. During the eclipse of December, 1870, Professor Newcomb employed the method suggested by Mr. Proctor a few months earlier, concealing the lighter part of the corona, and thus enabling the eye to search more effectually for the fainter light of the zodiacal.

But he failed on that occasion, the air being hazy at his station, and the circumstances otherwise unfavourable for an observation of so delicate a nature. Last July he repeated the attempt, and was rewarded with complete success. Stationed high above the sea level, and observing through an atmosphere of the utmost purity, he was able to trace a faint luminosity outside the corona proper, to a distance of six degrees from the eclipsed sun, nearly in the direction of the ecliptic. Professor Langley, on the summit of Pike's Peak, 14,200 feet above the sea level, saw the corona elongated in the same direction as the ecliptic. He says: "It resembled the zodiacal light; I followed it in the most transparent atmosphere to a distance of twelve diameters of the sun on one side, and three on the other." Professor Cleveland Abbe, who was to have observed the eclipse from the same station, was taken ill the day before, and had to be removed to the Lake House (hotel), 10,000 feet above the sea level. He had no instruments. But having recovered sufficiently by Monday afternoon to be carried out to a slope facing westward, he then observed the corona with the naked eye during the whole of totality. He did not notice the faint luminosity, extending to a distance of twelve solar diameters, which Newcomb and Langley saw, but he obtained a more satisfactory view of coronal details (may we not almost say zodiacal details?) to a distance of about six diameters. In the direction of the

ecliptic he saw a long pointed ray on the east of the sun, extending to this distance, while on the west of the sun, and as if forming a prolongation of the pointed ray, was a fan-shaped ray only about half as long. At right angles to these long rays were two others forming a similar system, the uppermost was pointed, and extended to a distance of about five diameters, the lowest was fan-shaped, and extended to a distance of about one and a half diameters. Professor Abbe considers that these were meteor systems—"not such meteors as some suppose to be falling into the sun daily, but the grand streams of meteors that cause the numerous shooting stars of August and November, and of the existence of which there is indubitable proof." In this form his explanation is certainly untenable, for the position of the August and November meteor systems is known, and they could not possibly have presented the appearance observed by Abbe. Nor, indeed, is it possible that these systems could be visible during total eclipse, for they are too sparse and too far from the sun. Whether other meteor systems much denser, and more fully illuminated because nearer to the sun, can explain the appearances seen by Professor Abbe, is a question not to be quite so readily answered. But the probabilities seem enormously against the theory that separate meteor systems produced the observed phenomena. Probably the radial extension of the light is to be explained in the same way as the extension of comets' tails in the direction from the sun. But as yet this phenomenon has not been explained satisfactorily.

The theory that the outer regions of the corona, and especially the long rays, are either merely subjective phenomena, or phenomena of our own atmosphere, has been finally overthrown by the eclipse observations.

The Corona during the late Eclipse.—It was generally agreed that the inner corona was much less extensive than during the eclipses of 1870, 1871, but that it was very bright to a height of 5′. In some accounts it has been stated that the spectrum of the corona did not show the green line 1474 Kirchhoff. But Professor Eastman traced it on all sides to a distance of two-fifths of the sun's diameter from the moon's edge. Mr. Thomas, and other observers, also saw this line. It seems clear, however, that the gaseous matter to which this line is due did not extend nearly so far from the sun as on former occasions.

Photographing the Corona's spectrum.—It has been asserted that the spectrum of the corona was photographed on this occasion in such a way as to show that those (including Captain Noble, and Messrs. Proctor, Ranyard, and Brothers) who predicted, in 1875, the failure of the methods proposed for photographing the corona, were altogether mistaken. This, however, is remote from the truth. In 1875 a method was proposed, which involved, among other objectionable features, the use of a prism in front of the object glass. And what was then aimed at (what, in fact, was promised by those who planned the operations), was that separate views of the corona by the green light corresponding to 1474 Kirchhoff, and by the light corresponding to the hydrogen lines, would be obtained for comparison with photographs of the corona by the whole of its light. In other words, we were told that by this method it would be possible to show how far the hydrogen constituent, and how far the constituent corresponding to the line 1474 Kirchhoff, extended into the corona as seen by the naked eye, or as photographed. It

was this that the objectors said could not be achieved by the plan then proposed. If new plans had succeeded, during the recent eclipse, in achieving that very result the objectors would not have stood corrected. By the use of the Rutherfurd grating the chance of success was unquestionably greater than it had been in 1875. Moreover, terrestrial conditions during the recent eclipse were altogether more favourable than those of the eclipse to which their remarks related. But in reality, notwithstanding the greatly increased chances of success, and a marked improvement in the method of attack, the attack has failed as completely on this occasion as it failed in 1875. The spectrum of the corona has indeed been photographed. No one ever said that this could not be done, or even that it involved any difficulty. The spectral images of the corona, however, were not shown, even near the sun, where we know (from the observations of Eastman, Thomas, and others) that they undoubtedly existed. Dr. Draper, Professor Thorpe, and Mr. Lockyer all photographed the spectrum of the corona; but as Mr. Lockyer says, who certainly was not disposed to minimize their success, "we had photographed as continuous a spectrum as if a platinum wire or ball in a state of incandescence had been in front of our instrument, instead of a shell of hydrogen gas 6′ high as in 1869, 10′ high as in 1871." In other words, the method entirely failed to do what it had been expected to do, and what in 1875 Mr. Lockyer and others had promised for it. We do not doubt that the circumstances were in reality far less favourable than they had been in 1869, 1870, and 1871. For the 1474 line was very faint, F alone of the hydrogen lines could be seen, and no observer saw the spectral *images* (as distinguished from the spectral *lines*) of the corona at all. But to describe the failure of the method, however brought about, as involving the disproof of objections formerly urged against it, is absurd in the extreme. The objectors said the method would certainly fail in 1875, and it did then fail entirely. They were doubtful whether the improved method devised for the late eclipse would succeed, and it has not succeeded. Hereafter, under more favourable conditions, and with improvements in photographic appliances, a method may be devised for obtaining photographs of the spectral images of the corona; but that certainly has not been done yet, nor if it had been done would it have shown that the objections urged in 1875 were invalid. The validity of these objections was, in fact, demonstrated effectually and definitely by the results obtained during the eclipse of that year.

Polarization of the Corona.—The majority of the observations showed that the corona was polarized radially. But Professor Hastings believes that he obtained satisfactory evidence of tangential polarization. He explains what he saw by the theory that there are ice-crystals in the corona—which, to say the least, seems unlikely.

Heat of the Corona.—By means of his wonderfully delicate heat-measuring instrument, the tasimeter, Mr. Edison succeeded in proving that the corona emits or reflects an appreciable amount of heat. He was not able to measure the heat of the corona, however, in this way, simply because the instrument proved to be too delicate. The indicator went quite off the field of view, and before it could be brought back totality was over.

Intra-Mercurial Planet.—Professor Watson and Mr. Swift both recognized a star of the 4th magnitude, or rather less, close to Theta Cancri. Watson found that it had a recognizable disc with a magnifying power of only 45.

If it was not the bright nucleus of a comet it must have been a planet. It appears, from calculations made by Gaillot, director of the Bureau des Calculs, that the observed place of the stranger agrees fairly with one of the orbits assigned by Leverrier to Lescarbault's Vulcan. If it should turn out that the stranger really is Vulcan, this planet travels round the sun in a period less than that in which the sun rotates on his axis. Its period is about $24\frac{1}{4}$ days, its synodical period about 26 days, its mean distance from the sun about 15,000,000 miles. Professor Watson remarks that in superior conjunction the star may appear of the first magnitude. But if he could detect no departure from the circular form (and he writes "there was no appearance of elongation such as might be expected if it were a comet") the planet could not have been far from superior conjunction. Yet Gaillot says "that if the new body were Vulcan, only a very small part of the disc would have been illuminated." The inference seems to be that either Gaillot's theory of the new body must be erroneous, or else Watson's failure to recognize any departure from circularity was inexact to a very remarkable degree. On the whole, while the existence of an unknown body close to the sun on July 29 last seems very clearly made out, the identity of this body and Lescarbault's Vulcan seems very far from being established.

Magnetic and Electric Action in the Sun's Atmosphere.—M. Cornu, from an investigation of his spectroscopic observations, has arrived at the conclusion that the dark lines in the solar spectrum indicate the action of an absorbing atmosphere similar in its constitution to volatilized meteorites. From this he infers that the enormous mass of the sun's atmosphere, containing, like the meteorites, a large proportion of the vapour of iron, exercises an appreciable action on terrestrial magnetic phenomena, so that the diurnal variations of the needle would on this view be due to the direct magnetic action of the sun. He argues that, although iron when heated to incandescence loses its attraction on the magnet, it has not been proved that the attractive force is reduced rigorously to zero, and there may be sufficient left to exercise a very appreciable action on the earth. M. Cornu also considers that the earth, having probably a common origin with the sun, may also be largely composed of iron—a supposition which would explain terrestrial magnetism. Considering that the solar prominences show a spectrum identical, in the relative brightness and sharpness of the lines, with that of highly rarefied hydrogen rendered incandescent by the electric discharge, M. Cornu thinks it probable that, appearing as they do in the neighbourhood of faculæ and spots, they represent masses of gas traversed by induction currents in the neighbourhood of magnetic or electric regions in rapid motion, and that, as M. Fizeau has already pointed out, they are analogous to the terrestrial aurora. The prominences being, on this view, simply due to the illumination by induction currents of masses of rarefied gas, their rapid extension and sudden disappearance would be explained without having recourse to the hypothesis of jets of gas having velocities of hundreds of miles in a second.

Planetary Phenomena for the Quarter.—Neptune will be in opposition to the sun on October 31, at 10 P.M. Venus will be in superior conjunction with the sun on December 5, 6 P.M. Mercury will be in superior conjunction on October 24, at 8 P.M., and at its greatest easterly elongation ($20\frac{3}{4}^{\circ}$) on December 8, at 4 P.M.

BOTANY.

Insectivorous Plants.—M. Hochstetter argues in opposition to the opinion put forward by Darwin and adopted by many naturalists, that the insects captured by various plants serve them as nourishment. ("Württemb. naturwiss. Jahreshefte," 1878, p. 106.) He divides insecticidal plants into three categories:—1, Those which emit a tenacious fluid from various parts to which insects stick; 2, those which possess special organs (pitchers, &c.), into which insects make their way, and are either drowned in a fluid contained in the cavity or prevented from escaping by hairs or other mechanical means; and, 3, those which capture insects by means of irritable leaves or glandular hairs.

The first group, which is very numerous, has never been supposed to derive any benefit from the captured insects. This is not the case with the second, including the pitcher plants, &c., for the insects drowned in the fluid contained in the cavities presented by their peculiar organs are believed to aid in the nutrition of the plants. M. Hochstetter says that, so far as he knows, nothing has been ascertained in support of this opinion; [but it has been shown that the fluid from those pitchers exerts a digestive action upon animal substances, and contains a principle related to pepsine, although, we believe, no one has attempted to show how the products of such digestion may be absorbed by the walls of the cavity]. M. Hochstetter says that his observations on *Nepenthes*, *Sarracenia*, and *Cephalotus* show most clearly that the pitchers of those plants which contain many dead insects die off much sooner than those in which none or few are to be found.

It is in the third group that the most striking instances of supposed insectivorous plants are to be found. Of these it has been affirmed that, after insects are captured, the plants excrete an acid fluid at the points where they are in contact with their victims; that this is allied to propionic acid and even contains pepsine; and that by means of it the soft parts of the insects are digested just as if they were in the stomach of an animal.

The author notices the peculiarities of the three genera, *Drosera*, *Drosophyllum*, and *Dionæa*, upon which most of the observations in this direction have been made, and, whilst giving all credit to Mr. Darwin for his valuable investigations upon this interesting subject, urges certain objections against the view that the plants are nourished by the insects they capture. His first objection, that the leaves of plants are not organs for the reception of nourishment, does not appear to be of much weight. In the second place, he remarks that the insects captured by the leaves either dry up or putrefy; and in the latter case, according to his observations, they do not produce better vegetation, but the destruction of the leaf-tissue implicated, as he has frequently noticed both in *Dionæa* and *Nepenthes*. In *Drosera*, however, stronger growth of the neighbouring parts of the leaf, sometimes perhaps of the whole leaf, does occasionally take place. But, says M. Hochstetter, we know that whenever vegetable tissues are exposed to friction, and especially when leaves are pierced by insects, or eggs are laid in their cellular tissue, cellular growths occur; and he indicates that in *Drosera*, vesicular inflations are produced on the leaves at the points where the insects lie.

The fact that an increased secretion of fluid takes place from the glands of

the leaves, and that the contents of these glands are altered, which has been regarded as evidence of the digestion of the captured insects, is regarded by M. Hochstetter rather as a sign of injurious action, such as is produced by acids and gases noxious to the life of the plant. He refers to the injurious action of ammonia upon plants placed in a fresh hotbed with the frames closed; and considers the saccharine excretion of leaves attacked by aphides to be a morbid phenomenon analogous to the increase of the fluid excretions in the plants in question. Thirdly, he remarks that *Dionæa* cultivated under bell-glasses are much stronger and more healthy than those grown in the open and allowed to catch flies. From all this M. Hochstetter concludes that the necessity or even the usefulness of the digestion of insects by plants is still far from being incontestably proved.

Milk of the Cow-tree.—M. Boussingault, when at Maracay, in South America, made a rough examination of the milky fluids furnished by this celebrated tree (*Brosimum galactodendron*), which is widely distributed in tropical America. He obtained from it—

1. A fatty substance like bee's-wax, fusible at 50° C., partially saponifiable, very soluble in ether, but slightly soluble in boiling alcohol. This substance when melted and cooled resembled virgin wax, and candles were made of it.
2. An azotized substance analogous to caseum.
3. Saccharine matters.
4. Salts of potash, lime, magnesia, phosphates. The quantity of solid matter in the milk was estimated at 42 per cent.

Samples of this milky juice sent to the Paris Exhibition of the present year, gave a dried extract, 100 parts of which furnished—

Wax, fatty matter	84·10
Sugar, inverted	2·00
Sugar, inversible	1·40
Gum, saccharifiable	3·15
Caseum, albumen	4·00
Ash, phosphates	1·10
Undetermined non-nitrogenous substances	4·25
	100·00

Which, brought to milky juice containing 42 per cent. of solid matter, gives—

Wax and saponifiable matters	35·2	
Saccharine and analogous substances	2·8	
Caseum, albumen	1·7	4·0
Earths, alkalies, phosphates	0·5	
Undetermined substances	1·8	
Water	58·0	
	100·0	

Thus in its general constitution, the milk of the cow-tree approaches cow's milk, except that it contains about three times as much solid matter; so that it is rather to cream that we must compare this vegetable milk. A cream analysed by M. Jeannier gave—

Butter	34·3
Sugar of milk	4·0
Caseum and phosphates	3·5
Water	58·2
	100·00

The butter here is nearly in the same proportion as the waxy matter in the milk of *Brosimum galactodendron*; and as fatty matters susceptible of being split into acids and glycerine are assimilable, it is easy to understand the nutritive properties of the latter.—*Comptes rendus*, August 12, 1878.

CHEMISTRY.

Atmospheric Hydrogen Peroxide.—There has recently appeared in the "Berichte der deut. chem. Gesellschaft" a very exhaustive report by Em. Schöne of Moscow on the amount of peroxide of hydrogen present in air and in atmospheric deposits. It is divided into four parts (see vol. xi. pp. 482, 561, 874, and 1028), and gives the details of a lengthy investigation, extending from July 1, 1874 to June 30, 1875; it is one which has evidently been conducted with wonderful patience and care. During the year he examined 215 specimens of rain and hail, and snow and sleet were tested on 172 occasions, making altogether 387 specimens submitted to examination. Seven samples of rain and 86 of snow appeared to contain no peroxide, or so small a quantity that it was left open to doubt and was recorded as O. The deposits brought by the equatorial currents always contained more peroxide than those falling at times when the polar current opposed them; and when the polar stream of air predominates the relatively smallest yield of peroxide is obtained. The amount attained a minimum in December and January, very slowly increased till April, was very much higher during May and June on to July, when it culminated. During the next three months it fell rapidly, and in November again very slowly approached the minimum. The hail of summer contained a comparatively large amount of the peroxide, although it is less abundant in hail than in rain; and the winter rain yields more of this compound than snow falling at the same period. The total amount of hydrogen peroxide which reached the earth's surface during the year is computed by the author to have amounted to 109·4 milligrammes to the square metre, that is to say in 599·9 litres of water, or 1·049 kilog. to the hectare. The peroxide present in the air in a state of vapour was collected and determined by producing artificial dew with the aid of freezing mixtures, and it was found that the rise and fall in the amount so obtained corresponded and went hand in hand with the numbers obtained by testing the atmospheric deposits. The diurnal variation was studied, and it was ascertained that the maximum amount was present at about four o'clock in the afternoon, after which it diminished, the minimum being attained between midnight and 4 A.M. The air of a large hall, which had been unoccupied for four weeks and the windows of which were closed but were not air-tight, was observed to contain an average of

0·17 c.c. peroxide in 1,000 cubic metres. In dew artificially deposited in a badly ventilated room there was no peroxide; its presence, however, became manifest as soon as the windows were thrown open. Dew and hoar frost deposited during the last hours of the night appeared to be pure water; in dew collected during the evening hours peroxide was met with, the amount being 0·05 gramme to the litre. The peroxide is present in fog, and is apparently more abundant in spring than in autumn. The amount of peroxide present in any atmospheric deposit varies with the altitude at which that deposit has been formed; the greater the altitude at which the condensation takes place, the greater is the quantity of peroxide which it will contain. This is doubtless due to the decomposition which that substance must undergo when exposed to organic vapours rising from the earth's surface. In the air itself there is but little peroxide, the maximum quantity observed being 14 c.c. in 1,000 cubic metres of air. The author points out the scientific advantages which would attend systematic observation in this field at our meteorological stations.

Cast Manganese.—Jordan has presented to the Academy of Sciences of Paris a specimen of fused manganese, obtained by smelting manganese ores in the blast furnace. About 10 per cent. of the metal is lost during the operation, and it seems not improbable that the metal is volatile at higher temperatures. The manganese appears to be very stable, the specimen above referred to having undergone no perceptible change in six months. It consists of

Manganese	84·960
Iron	8·550
Carbon	5·700
Silicium	0·660
Sulphur	0·035
Phosphorus	0·005
	99·910

In one specimen the percentage amounted to 87·4.—*Compt. rend.* 1878, No. 22.

Expansion of Bismuth.—Marx directs attention to an experiment which admirably illustrates the force with which a metal like bismuth expands during the act of solidifying. He dips a long and narrow glass tube into the melted metal, and sucks it up the tube to a height of eight or ten inches. On allowing it to cool, the tube is shattered, often with explosive violence. The tube cracks along its length, and is broken up into long parallel glass rods or threads, which it would be difficult to produce by any other means.—*Pol. Notizblatt*, xxxiii. 44.

Absorption of Carbonic Oxide by the Blood.—Gréhart's experiments on this subject have led him to the conclusion that if a man or animal be placed for half an hour in an atmosphere containing 1-779th of carbonic oxide, one half of the red corpuscles will have taken up sufficient of the gas to render them unable to absorb oxygen; by exposure to an atmosphere containing 1-1449th of carbonic oxide, about one-fourth of the red corpuscles are rendered inactive.—*Compt. rend.*, 1878, lxxxvi. 895.

Alum and Dysentery.—Dounon's observations go to show that dysentery

caused by the introduction of *Anguillula stercoralis* and *dysenterica*, *Ankylstoma dysenterica*, &c. into the intestinal canal by means of polluted water, may be avoided by dissolving alum in the water, although this is, of course, a less desirable method than that of boiling the water. The treatment with alum has, it is said, been successfully used by the natives of Annam from early times; while for several years it has completely protected the French troops in Cochin China from this dreadful scourge.—*The Chemical News*, 1878, xxxviii. 24.

An interesting *résumé* of the present state of our knowledge of the synthetical processes which are in operation in the bodies of animals has just been published by E. Baumann. It is entitled: "Ueber die synthetischen Processe im Thierkörper" (Berlin: Hirschwald, 1878).

Magnesium Nitride.—Mallet obtains this compound by burning the metal in a limited supply of air. The band of magnesium when ignited is to be held well down in a porcelain crucible. If filings of the metal be used the same result is obtained, and with far greater completeness. The residue has a well-marked greenish-yellow colour, and evolves abundance of ammonia when moistened with water or a solution of a caustic alkali. When only a few drops of liquid are added the heat evolved is sometimes so great as to ignite a portion of the mass, and much of the powder is scattered by the escaping ammonia and aqueous vapour. In three analytical estimations of the results of the reaction it was found that 23·5, 27·5, and 24·8 per cent. of nitride were respectively formed.—*The Chemical News*, 1878, xxxviii. p. 39.

The Dissociation of Sulphides.—The hydrates of metallic sulphides are decomposed by water when boiling, as well as at lower temperatures, sulphuretted hydrogen being evolved and a metallic oxide formed. This is true of the majority of the sulphides, those of copper, bismuth, and mercury proving exceptions. Arsenic trisulphide is dissociated at the boiling-point into hydrogen sulphide and arsenious acid. De Clermont and Frommel have devised a method for the separation of arsenic from metallic sulphides which is based on this reaction. The mixed sulphides are to be suspended in water and boiled. The dissociation is soon complete. If the mixture weigh 5 to 6 cg. the liquid should be boiled from twenty to twenty-five minutes. All remaining sulphides give insoluble oxides, which can readily be separated from the soluble arsenious acid.—*Bull. Soc. Chim.*, Paris, 1878, xxix. p. 290.

The Solubility of Bottle-glass.—Macagno has determined the degree of solubility in water of a number of specimens of bottle-glass derived from different sources, and ascertained in each case "the corrosion degree" of a boiling solution of potassium bitartrate. He finds that the chemical composition of bottle-glass is hardly a correct indication of its quality. The amount of alkali or lime does not express the resisting power of the glass to water or acids. While the French glass is of very superior quality, the Rhenish, Madeira, Malaga, and Xeres bottles appear to have a very inferior composition. In order of colour we must set deep green in the first rank, in the second the white and common green, then the clear green, next the red-brown, while the worst are the yellow-brown, which must be regarded as likely to contaminate ordinary wines containing much potassium bitartrate. In the case of the deep green glass of a Burgundy bottle the corrosion degree was 1·275; white glass, used for Rhenish, Bordeaux, and

Chianti, 2·020; common green glass, used for Rhenish, Bordeaux, Champagne, &c., 3·202; yellow-brown glass, used for Bordeaux, Madeira, Malaga, &c., 3·387; and the red-brown, used for Rhenish, Ruster, Rohitscher, &c., 4·888.—*The Chemical News*, 1878, xxxviii. p. 5.

The Solubility of Platinum in Sulphuric Acid.—Scheurer-Kestner has continued his inquiry into the solubility of this metal in concentrated sulphuric acid, and finds that while the action of a 95 per cent. acid is a very marked one it becomes still more notable when the concentration exceeds that corresponding to the monohydrate. With the hope that platinum apparatus might be adapted to the manufacture of Nordhausen acid on a large scale, sodium bisulphate was fused in a glass retort lined with platinum foil, and the vapours were condensed in stone vessels. A number of experiments were made in this way with an apparatus the platinum of which weighed 5 kilog., and it was found that for every 100 kilog. of acid distilled 100 grammes of metal were dissolved in the sodium sulphate. In the earlier experiments 100 kilog. of 94 to 99 per cent. acid dissolved 1 to 8 grammes of metal.—*Comptes rendus*, 1878, lxxxvi. p. 1082.

Invertin.—This, the inverting constituent of yeast, to which Donath gave the above name, has been submitted to a long investigation by Barth (*Ber. Deut. Chem. Gesell.*, 1878, xi. 474). To obtain it he coarsely pulverises fresh compressed yeast and dries it at temperatures not exceeding 40° until it can be rubbed to powder between the fingers; it is then heated to 100° or 105° for six hours, mixed with water in considerable quantity, and after having been allowed to stand for twelve hours at 40° the insoluble portion is removed by filtration. The filtrate, which has a yellowish hue, is poured into six times its volume of alcohol containing 95 per cent.; this causes the formation of a white flocculent precipitate, which when violently agitated becomes granular, and then may easily be collected on a filter. The albuminates which are likewise thrown down by the alcohol can be removed by treating the precipitate with a limited amount of water, when they remain undissolved as a gelatinous mass. A second treatment with alcohol yields the ferment in a pure state. Two grammes of the ferment are obtained from 500 grammes of yeast. Invertin is a white powder, which dissolves in water, forming a yellowish-brown solution; this is not rendered turbid when boiled with acetic acid and salt, and is thus shown neither to be an albuminate nor to contain one as an impurity. When boiled with dilute copper solution and sodium hydrate it does not strike a violet colour; this indicates an absence of peptones. After heating some for a long time with sulphuric acid no leucin could be found. Analysis showed invertin to contain 22 per cent. of ash, consisting of potassium, calcium, and magnesium phosphates. If the inorganic constituents be excluded, the ferment contains: carbon, 33·9 per cent.; hydrogen, 8·4 per cent.; nitrogen, 6·0 per cent; sulphur, 0·63 per cent.; and oxygen (by difference), 41·17 per cent. The activity of invertin appears to be dependent on the degree of concentration of the sugar solution, and is proportional to the amount of ferment present; it reaches its limit in about forty hours. One part of invertin can produce 760 parts of inverted sugar.

Tinfoil and Tinplate.—Kopp and Engel have recently examined specimens of the tinfoil used in packing French chocolate. Traces only of lead were

found, and the composition of the metal, they consider, contrasts favourably with the so-called tin used for similar purposes in England. We find, however, that one sample of the foil which they analysed contained 6·111 per cent. of antimony and 0·889 per cent. of arsenic. The metal which coats "tin-plate" is more easily attacked and dissolved than is generally supposed. Menke detected the presence of 0·1513 gramme of tin in a "canned" pine-apple weighing 1¾ lbs., 0·0101 gramme of that metal in a tin of lobster, and 0·0067 gramme in one of apples.

GEOLOGY AND PALÆONTOLOGY.

A new Pre-Cambrian formation.—Dr. Hicks, whose establishment of the Dimetian and Pebidian formations we noticed last year (*P. S. Rev.*, N. S., Vol. I., p. 96), states in a communication to the British Association that he has found that the Pre-Cambrian rocks occupy many areas in Wales, and that they resolve themselves into three well-marked types, which he regards as separate formations, as they prove on examination to be unconformable to each other. At St. David's granitoid rocks occur at the base; resting unconformably upon these come quartz-felsites; which again are succeeded by the agglomerates, breccias, greenstone-bands, and schists of the Pebidian group. In North Wales the same order of succession was observed, but the middle, or quartz-felsite group, was more largely developed in Caernarvonshire, and hence Dr. Hicks proposes to name it *Arvonian*, from the Roman name of the district (Arvonia). The name is appropriate, as many of the mountains of Caernarvonshire consist of these rocks. Dr. Hicks thus distinguishes these Pre-Cambrian formations, namely:—

1. *Dimetian*, granitoid gneiss rocks.
2. *Arvonian*, quartz-felsites and porphyries (Halleflinta of Torel; petrosilex rocks, Hunt).
3. *Pebidian*, green and purple agglomerates and breccias, green chloritic schists, with massive greenstone bands, talcose schists, &c.

In these formations the bedding is usually easily recognized, but the actual stratigraphical thickness cannot yet be precisely estimated, although, from the sections exposed, Dr. Hicks infers that each of them must be many thousand feet thick, and their horizontal extension is also evidently very wide.

Fossil Mammals of South America.—From an examination of numerous remains of Mammalia, lately brought to Paris from Brazil and La Plata, M. Paul Gervais has obtained some important results. He regards *Toxodon* as nearly allied to the Porcine Mammals, and as probably agreeing with the Hippopotamus in its habits; but although it resembles that great old-world Pachyderm in some of its characters, it possesses others which indicate that it must have nearer allies which are still unknown. The Solidungula have no well-marked representatives from the region of La Plata, except the horses known as *Hippidia*. No remains of Tapirs have been found with these; but a fragment of the symphysis of a mandible, having traces of two canines with two incisors between them, seems to indicate an animal resembling *Rhinoceros* in this part of its dentition.

A large *Machairodus*, of which a nearly complete skeleton has been obtained, differs from the great Brazilian species (*Machairodus neogæus*) in the form of the skull, and in having only two instead of three lower molars. M. Gervais proposes to call it *M. necator*.

The remains of Glyptodonts confirm the separation of those animals into several genera, as proposed by Burmeister. One of them is described as a new species under the provisional name of *Glyptodon rudis*, but the author is of opinion that it will constitute the type of a new genus. Its bony plates are quadrangular and rough on the outer surface, but without rosaciform tubercles, and without radiating lines. The rings of the caudal sheath are composed of separate pieces, which interlock after the same fashion as the dorsal plates. Another undescribed species, of which only a small portion has been brought, seems to be nearly allied to *Hoplophorus*, but is distinguished from the known species of that genus by its bony plates, which consist of a smooth central polygonal disc with blunt angles, having on its sides smaller smooth plates in the form of arcs of a circle. The author names this species *Hoplophorus discifer*. M. Ameghino, one of the collectors of these fossils, has also obtained in the La Plata region numerous objects of human workmanship, some of which are believed to date back to the period of the great extinct Mammals. (*Comptes rendus*, June 3, 1878.)

An American Jurassic Pterodactyle.—Professor Marsh describes (*Silliman's Journal*, September 1878), the first indication of a Pterosaurian from American rocks older than the Cretaceous, the species found in which are generally of gigantic size, and so far as is known belonged to that toothless group of these reptiles which Professor Marsh proposes to name Pteranodontia. The specimen now described is from the "Atlantosaurus beds" (Upper Jurassic) of Wyoming, which have lately yielded the remains of so many interesting forms of reptiles. It is the distal portion of a metacarpal bone of the right wing, and indicates a Pterodactyle with an expanse of wings of four or five feet. Its shaft shows an oval section, but near the condyle becomes subtrihedral, with a distinct ridge on the under surface. It is hollow, with thin, smooth walls. The outer condyle is placed obliquely, as in the Cretaceous species; the lower groove between the two condyles is unusually narrow; and the inner condyle is nearly circular in vertical outline. The fragment presents no characters by which its generic relations can be established, and Professor Marsh describes it under the provisional name of *Pterodactylus montanus*.

Geology of Sind.—Mr. W. T. Blanford has communicated to the Asiatic Society of Bengal ("Proc.," January 2, 1878) some notes on the geology of Sind, a map of which has just been completed by the Indian Survey. The greater part of the province consists of the alluvial flat of the Indus, but in the west ranges of hills occur containing Tertiary and, as is now believed, Cretaceous rocks. A thin flow of basalt supposed to represent the Deccan traps underlies the undoubted Tertiaries. Mr. Blanford gives the following table of the beds of Sind:—

Name	Sub-divisions	Approximate thickness	Supposed Geological age	Remarks
1. ALLUVIAL, &c.	—	Unknown	Recent and post-tertiary	—
2. MANCHHAR .	Upper . . .	5,000	Pliocene	Apparently representative of the Sevaliks proper
	Lower . . .	3,000 to 5,000	Lower Pliocene or Upper Miocene	—
3. GÁJ	—	1,000 to 1,500	Miocene	—
4. NARÍ . . .	Upper . . .	4,000 to 6,000	Lower Miocene	—
	Lower . . .	100 to 1,500	Upper Eocene	—
5. KHIRTHAR. .	Upper . . .	500 to 3,000	Eocene	Nimmulitic Limestone
	Lower . . .	10,000 (?)	Eocene	Base not determined
6. RANIKOT . .	—	2,000	Lower Eocene	—
7. TRAPS . . .	—	40 to 90	Upper Cretaceous	Representative of Deccan and Malwa Trap
8. CRETACEOUS .	*Cardita Beaumonti* beds. .	350 to 450	Cretaceous	—
	Sandstones .	700		—
	Hippuritic Limestone .	320		Base not exposed

The most interesting point in this investigation is the asserted discovery of Cretaceous rocks in the hills of Western Sind. The lowest bed, the Hippuritic limestone, has only been found in one spot, and there the outcrop is not more than half a mile in length. The only recognizable fossil found was a Hippurite. This limestone is believed to be identical with the Cretaceous limestone which occupies a large area in Persia, and has been traced at intervals from south-east of Karmán to near Teherán. If so, this is the first recognition of the formation in India except in the Himalayas. The sandstones above the limestone are dark, often calcareous, and not very fossiliferous. Towards the top they contain oysters and a few apparently reptilian bones. Above these are olive clays, shales, and sandstones, containing a peculiar globose *Cardita* (*C. Beaumonti*), two or three species of *Nautilus*, and corals. The thin bed of trap has been traced for about 22 miles, always above the olive clays and beneath the lowest Tertiary beds; the author regards it as undoubtedly identical with the trap of Málwa and Guzerat. The Ranikot group in its lower portion contains only imperfect plant remains; but the limestones intercalated in its upper part abound in Mollusca, Echinodermata, and Foraminifera. Many of the fossils pass up into the overlying Khirthar beds, including *Nummulites Leymeriei*, the only abundant nummulite here. A few species show Cretaceous affinities, especially a *Salenia* and some *Nautili*. The Khirthar group is more widely distributed, and where best developed is the most conspicuous formation in the province,

consisting of massive whitish and grey limestone, abounding in nummulites and other Foraminifera, associated with corals and mollusca. The commonest species are *Nummulites granulosus, biarritzensis, Leymeriei, spira, Ramondi,* and *obtusus, Alveolina ovoidea, Orbitoides dispansus,* and *Nerita Schmiedeliana.* The Narí beds also contain nummulites, but not of the Khirthar species, which are replaced by *N. garansensis* and *sublævigatus* and *Orbitoides papyraceus.* The Gáj group is highly fossiliferous, but no nummulites have been found in it; an *Orbitoides,* apparently *O. papyraceus,* occurs. The Manchhar, or highest Tertiary, is of great thickness, and probably represents the Sevaliks of Northern India, but the genera of mammalia are generally older, forms like *Dinotherium* and *Merycopotamus* prevailing.

The Ursa Stage in Siberia.—M. J. Schmalhausen ("Bull. Acad., St. Petersb. tome xxv. p. 1) records the occurrence in Eastern Siberia of beds belonging to the infracarboniferous series denominated by Professor Heer the "Ursa Stage," on account of their having first been recognized by him in Bear Island. The existence of such deposits had been previously indicated by the author on the evidence of fossil plants obtained from travelled blocks, one of which he identified with *Cyclostigma kiltorkense.* The rocks containing plants characteristic of the Ursa Stage have now been found *in situ* in various places in the Government of Jenissei, chiefly in the banks of the river of that name and its affluents, as far south as 53° N. lat. The most important locality is the Issyk mountain, on the right bank of the river Abakan, near its junction with the Jenissei, which consists chiefly of a mass of reddish-brown sandstones, with interstratified greenish sandstones, overlain by a lighter-coloured mass, formed by interstratified greenish sandstones, limestones, and yellowish calciferous sandstones. On the eastern and western slopes of the mountain these deposits are overlain by shales and sandstones, with beds of coal. The impressions of plants were obtained from the light-coloured sandstones and the coal-bearing shales, those from the latter being well preserved.

The principal plants obtained from this and other neighbouring localities, among which a mountain near the mouth of the river Trifonowa is the chief, are as follows:—*Bornia radiata,* Schimp., *Triphyllopteris Lopatini,* sp. n., *Neuropteris cardiopteroides,* sp. n., *Sphenopteris,* sp., *Lepidodendron Veltheimianum,* Sternb., *L. Wilkianum,* Heer, *Cyclostigma kiltorkense,* Haught., *Cordaites* (?) *palmæformis,* Göpp., *Cyclocarpus drupæformis,* sp. n., and *Samaropsis oblonga,* sp. n.

Currents of the Suez Canal.—M. de Lesseps has communicated to the Academy of Sciences ("Comptes rendus," July 22, 1878) the results of a series of observations worked out by M. Lemasson on the interesting question of the behaviour of the water in the great maritime canal. The author has treated in detail of the tides and currents of the Mediterranean and Red Sea at Port Said and at Suez, and their influence upon the waters of the Canal, and has also taken into consideration the question of the action of prevalent winds. It appears that Lake Timsah and the basin of the Bitter Lakes, the former in the middle of the line of navigation, the latter nearly at the middle of the southern branch of the Canal, constitute two great regulators, at which the tidal currents from the two seas respectively expire. The north and south branches of the Canal are not, however, independent as

regards the movement of their waters. The dominant winds in this region blow, from May to October, from the north and north-west, and raise the mean level of the waters of the Mediterranean at Port Said, whilst they depress the mean level at Suez. The difference of level, which attains nearly 40 centimetres (almost 16 inches) in September, sets up, in summer, a current from the Mediterranean to the Red Sea, which is interrupted by the tides, but nevertheless carries a considerable volume of water from north to south. In the winter, on the contrary, the south winds blow strongly, and the mean level of the Red Sea is then higher than that of the Mediterranean, the difference attaining a maximum of 30 centimetres (almost 1 foot). The general direction of the current of the Canal then sets from the Red Sea to the Mediterranean. The volume of water flowing annually from one sea to the other is estimated at about 400,000,000 cubic metres, and this, with the tidal currents, annihilates the effects of evaporation at the surface of the lakes, and aids the solution of the great salt deposit in the basin of the Bitter Lakes, which, instead of increasing, as was expected by some people, is actually diminishing, especially in the line of transit of ships. The tidal currents in the northern branch of the Canal between Port Said and Lake Timsah usually vary in velocity from 0·15 to 0·45 metre per second, but may attain 0·50 and 0·60 metre. Between Suez and the Bitter Lakes the width of the Canal being greater, the currents vary from 0·60 to 1·10 metre per second, and may attain 1·30 metre.

MINERALOGY.

Milarite.—The results of earlier analyses of milarite show so great a disparity that Ludwig has been induced to submit a pure specimen of this mineral to analysis. The mean of his numbers are:—

Silicic acid	71·81
Alumina	10·67
Lime	11·65
Potash	4·86
Water	1·36
	100·35

These determinations indicate $Si_{12}Al_2Ca_2KHO_{30}$ as that of milarite. Tschermak, who has investigated the optical properties of this mineral, finds each crystal to consist of at least six individuals, combined with each other in positions inclined at about 120°; they resemble in this respect crystals of aragonite, witherite, &c. The individuals appear to be twinned upon a face which, it seems, is to be regarded as ∞ P and all the crystallographic observations so far made point to milarite belonging to the rhombic rather than the hexagonal system.—*Jahrbuch für Mineralogie*, 1878, p. 411.

The Meteorite of Hungen.—Buchner and Tschermak have described the meteorite the fall of which was witnessed at Hungen, in the Province Oberhessen, on the 17th of May last year. A portion weighing 73 grammes, which has been sent to the University collection at Giessen, shows the black fused crust. The mass of the stone is grey, and presents chondritic characters; numerous enclosed particles of nickel-iron and troilite are to be seen scattered through it. Microscopic observations show the crust to consist to the

extent of one-half its weight of nickel-iron; the matrix is colourless and transparent. Tschermak, who has examined the specimen sent to the Vienna collection, finds it to closely resemble the stones which fell in such numbers at Pultusk in January 1868. The crust in the former case, however, is thicker. A careful examination of a section of the Hungen stone enabled Tschermak to detect the presence of particles of nickel-iron, some 1·5 mm. in diameter, as well as granules of magnetic pyrites. The mass of the stone contained abundance of chondra, some opaque and lustreless, consisting apparently of chromite or picotite, while the transparent ingredients are of three kinds: one the crystalline characters and optical orientation of which identified it with olivine; a second in granular fragments which appeared to consist of bronzite; and a third the angular particles of which had a finely foliated texture, resembling diallage or augite.—*Jahrbuch für Mineralogie*, 1878, p. 411.

Sodium Chloride.—Bertrand has described crystals of salt from the Soda Lakes of Egypt, some 1 cm. in diameter, which were either octohedra or octohedra combined with the dodecahedron and the cube. The majority of them were not transparent, and had a grey colour. Sodium chloride has been obtained in octohedra of very small size, and without any other planes, by crystallization from a concentrated solution saturated with sodium carbonate. —*Zeitschrift für Krystall. und Mineralogie*, 1878, p. 199.

The Rocks of the Island of Vulcano.—Cossa finds that the alum of this island contains a relatively large amount of the sulphates of cæsium, rubidium, thallium, and lithium, all of which salts are probably present in the form of alums; and it is stated by him to stand second only to the rare pollux of Elba as material for the preparation of cæsium compounds. The rocks overlying the alum beds appear to have furnished the cæsium and rubidium, which are present in them in the form of silicates. These have subsequently been converted into alums by the action of acid vapours. A reddish porous crystalline mass which collects on the floor of the crater contained considerable quantities of sulphates of lithium, cæsium, and thallium, only traces of rubidium and potassium, and, in addition, boracic acid, ammonium chloride, arsenic sulphide, and selenium sulphide. Cossa recommends antimony chloride for the separation of cæsium and rubidium, and states that Stolba's method with tin chloride did not yield satisfactory results in his hands. A gas escaping from a mineral water which bubbled forth near the crater consisted of carbonic acid, 79 vols.; nitrogen, 20·5 vols.; and oxygen, 0·5 vol. in 100 vols.—*Ber. deut. Chem. Gesell.* 1878, xi. p. 811.

The *Mineralogische Mittheilungen*, edited by Prof. Tschermak, since the issue of the first part in 1871, and published as a supplement of the "Jahrbuch der K.K. Geolog. Reichsanstalt," has ceased to appear; and in its place Prof. Tschermak will edit "Mineralogische und Petrographische Mittheilungen," which will be published independently, six parts to be issued each year. Two parts have already appeared. In addition to original articles they contain notices of memoirs which have appeared in other scientific journals.

Pseudobrookite and Szabóite.—Koch describes, under the name of pseudobrookite, a rhombic mineral from the Aranyer Berg, in Siebenbürgen, having the composition:—

Titanic acid	52·74
Iron peroxide	42·29
Alumina	Trace
Lime and magnesia	4·28
Loss by ignition	0·70
	100·01

The mineral is dimorphous with menaccanite or ilmenite. The crystalline form, habit, and the physical, and in certain respects also the chemical, properties of the mineral are those of brookite; but closer examination shows it not to be that mineral. Szabóite is a triclinic mineral, which closely resembles pyroxene in appearance. It is composed of:—

Silicic acid	52·35
Iron peroxide	44·70
Alumina	Trace
Lime and magnesia	3·12
Loss by ignition	0·40
	100·57

Chemical constitution and crystalline form at first sight recall babingtonite, but the resemblance is not supported by further investigation—*Mineralogische und Petrographische Mittheilungen*, 1878, i. 77.

PHYSICS.

Acoustic Repulsion.—It can be shown theoretically that the average pressure at the node in a column of air vibrating in stationary waves cannot be equal to zero as long as the amplitude of vibration is not infinitely small. M. Dvorak has made experiments in illustration of this fact. In a resonator open at one end, there is a node at the other. In the inside, near the closed end, there is greater pressure than outside. When such resonators are delicately suspended, and turned towards the source of sound, or the resonant box of a tuning-fork, the repulsion is so great that it is apparent even with an ordinary brass Helmholtz resonator, weighing with its counterpoise 142 grammes.

An "Acoustic Mill," showing continuous rotation, was made by fastening from very light paper, or thin glass, resonators on the arms of a light wooden cross, balanced on a glass cap, with their openings facing the same way towards the source of sound. Rapid rotation is obtained by using a large Knadt's tube as the source. If a cone of stiff paper be held with its large extremity towards the sounding body, and of such a size that it vibrates to the same note, on excitation, a current of air rushes from the smaller end with such violence as to be felt and heard, and to blow out a candle at the distance of 20 centimètres. It appears that these experiments had been independently made, and indeed anticipated, by Professor A. M. Mayer, of New York.

In a paper on the Physical Origin of Nebulæ, Dr. Croll endeavours to fathom the origin of the sun's heat. It must be ultimately derived either from gravitation or from motion in space: but whereas the former source of energy could not have exceeded from 20 to 30 million years' supply of heat at the present rate of radiation, the store derivable from motion in space dependent on the *rate* of that motion may conceivably have amounted to any assignable quantity. A mass equal to that of the sun, moving with a velocity of 476 miles per second, possesses energy sufficient to cover the present rate of the sun's radiation for 50 million years.

This motion of translation must be converted into molecular motion by *collision.* The only assumption the collision theory makes is the existence of matter and motion. Suppose two bodies, each one half the mass of the sun, approaching each other directly at the rate of 476 miles per second, their collision would transform the whole of the motion into heat, affording an amount sufficient to supply the present rate of radiation for 50 million years. Each pound of the mass would, by the stoppage of the motion, possess as much heat as would melt 90 tons of iron. The whole mass would be converted into an incandescent gas, with a temperature of which we can form no adequate conception—certainly more than 140,000 times that of the voltaic arc.

Effect of change of pressure on the length of disruptive discharge in air.—Mr. J. E. H. Gordon has been studying this at distances ranging from 6 to 30 inches by means of the same apparatus. This was a fine induction-coil, giving a spark of 17 inches long, worked by 10 cells of a Grove's battery. The discharging tubes were 4 feet long, and 3 inches in diameter, with a stuffing box at one end in which a brass rod slid. The inner end of the rod was kept in the axis of the tube by three little glass arms on an ebonite collar. The whole was insulated on ebonite legs. The tubes were connected with an air pump by means of an insulating glass tube. The pressure was given by a U guage about 4 feet high, and the air dried by passing it through sulphuric acid.

In the experiments one tube was left open to the atmosphere, and its discharging point placed at a standard distance from the ball. The other tube being nearly exhausted, experiments were begun at low pressure, a little air being let in between each observation. The discharging distance in the second was then adjusted to the shortest distance which caused the whole discharge to pass in the first tube. This being noted, the points of the second tube were again brought together until the whole discharge passed between them. The mean distance of the two observations was used.

The results were:—

1. From a pressure of 11 inches upwards the length of spark is inversely as the pressure.

2. Accidental circumstances materially modify the length of spark.

3. Below a pressure of 11 inches the spark is shorter than it should be by No. 1, the electro-motive force required to produce a spark of given length at low pressure being greater.

This agrees with Sir W. Thomson's experiments, from which it results that greater electro-motive force per unit length of air is required to produce a spark at short distances than at long. To this may now be added, at low pressure than at high. The cause seems to be unexplained.

The Harmonic Engine.—One of the most remarkable of Mr. Edison's many inventions is the so-called harmonic engine, which consists primarily of a large tuning-fork put into vibration by means of an electric current. With a small battery and a couple of electro-magnets, Mr. Edison has succeeded in getting sufficient power out of the vibrations of this "tuning-fork" to pump up a considerable quantity of water to the top of his house, to drive a sewing-machine, or to perform other work requiring small power. The "fork" consists of a couple of limbs, 2½ feet long, made of 2-inch square steel, the curved part being firmly held in a casting bolted to a solid foundation. Attached to the end of each arm is a 35lb. weight, and near each is a small electro-magnet, possessing sufficient power to set the arms in vibration. These vibrations, which are made at the rate of 35 per second, are of small amplitude, but are of sufficient power to work a little pump, the rapidity of the motion compensating for the smallness of the stroke. The machine is at present little more than a toy, but, its effectiveness having been demonstrated, further developments may render it a useful motor for employment in domestic work. Mr. Edison proposes to utilize the machine for compressing air, but it will probably be found more profitable to employ the power direct, instead of using it through that agency, the machinery for which must of necessity absorb a considerable quantity of the power in overcoming friction.

ZOOLOGY.

The Buzzing of Insects.—It has long been supposed that the buzzing of bees, flies, and other insects, was due to the friction of the air passing through the thoracic stigmata, after being set in motion by the action of the muscles moving the wings. After repeating the experiments on which this opinion is founded, M. Pérez comes to a different conclusion. He finds that when the wings of a fly are held so tightly that no motion of their bases is possible, no sound is produced; but, on the other hand, the removal of the scaly portions fringing the periphery of the stigmata, injury to the margins of the stigmata themselves, and stopping them with solid masses, leaves the buzzing unaltered, and even a hermetical closure of these apertures has only the effect of weakening the sound produced. In this last case the power of flight is weakened, owing, according to M. Pérez, to an asphyxia of the insect caused by the exhaustion of the air in the thoracic tracheæ, which is after a time made up by an influx of air from the abdomen, but the attempts at flight become weaker and weaker, and the animal speedily dies.

M. Pérez's interpretation of these phenomena is that the causes of buzzing reside solely in the wings. Cutting the wings influences the buzzing more or less, this becoming thinner and sharper and losing the softness due to the friction of the air upon the edges of the wings. The sound is different according to the amount of the wing removed, that is to say, the shortness of the stump, and it is in relation with the beatings of the stump against the solid parts which surround it, or of the horny pieces which it contains one against the other. If the section be carried down to sensitive parts the sound ceases; but this is because the animal ceases to perform movements which have become painful to it.

Of various buzzing insects the author says that, in the Hymenoptera and Diptera the buzzing is due to two distinct causes, namely, the vibrations of which the articulation of the wing is the seat, the true buzzing, and the friction of the wings against the air, which modifies the former more or less. In strong-winged Lepidoptera, such as the Sphingidæ, the buzzing is produced entirely by the friction of the air upon the wings; so also with the dragon flies.—(*Comptes rendus*, 2 September, 1878.)

Drone-Bees.—It is well known that, according to a theory of M. Dzierzon adopted and developed by Professor Siebold, the eggs from which drone-bees are produced in a hive are deposited by the queen without fecundation, and that the queen-bee can even fecundate the eggs or leave them unfertilized, according as they are intended to produce females or males. The theory was founded, at least in part, upon the supposed fact that an Italian queen, fertilized by a German drone, would produce hybrid-workers and queens (females) and drones exactly like herself. M. Pérez, however, disputes the genuineness of this fact, on the ground of observations made upon a hive in his possession, the queen of which, the daughter of an Italian of pure race, has been fertilized by a French drone. Some of the workers are Italian, others French, others mixed in various proportions of the two races. Among the males also he observed some as dark as those of the French race, although, according to the above theory, they ought all to have been of the Italian race, like their mother. He therefore carefully examined 300 of the drones, and obtained the following numbers:—

151 were pure Italians.
60 were hybrids of various degrees.
83 were French.

Hence he regards it as evident that the drone-eggs, like those of the females, are fertilized by contact with the fluid stored up in the seminal receptacle of the queen, and that Dzierzon's theory must fall to the ground. This theory, however, was supported by other facts and experiments; and it is a question whether M. Pérez's queen which he speaks of, guardedly, as the 'fille d'une Italienne de race pure,' was herself of pure Italian race.—(*Comptes rendus*, 9 September, 1878.)

Prosopistoma.—MM. Joly & Vayssière have examined the structure of this curious insect, only what appears to be the larval form of which is known, and the true position of which is consequently very doubtful ("Comptes rendus," August 5, 1878). In its form it resembles the Ephemeridæ, and especially the larva of the American *Bætisca obesa*, Say. It has the parts of the mouth usual in masticating insects. The respiratory system includes two kinds of organs: 1, the internal tracheal apparatus, represented by two main trunks, giving origin to numerous branches; 2, supplementary organs situated at the anterior part of the dorsal surface of the abdomen in a sort of cavity, the upper wall of which is formed by the thorax, and which communicates with the outer world by three openings—two placed laterally on the ventral surface, and a median aperture on the dorsal surface. This respiratory chamber contains a tracheo-branchial apparatus, consisting of five lamelliform or digitiform pieces on each side. These pieces move rhythmically, and cause the entrance of water by the ventral apertures, and its escape by the dorsal one. The authors give some details as to the internal structure of

the insects, and say that from the facts ascertained they are disposed to adopt Mr. McLachlan's opinion, that *Prosopistoma* is an Ephemerid, probably adapted permanently to an aquatic life.

Abnormal Dentition in a Tiger.—Mr. Lydekker describes and figures ("Journ. Asiatic Soc.," Bengal, 1878) the lower jaw of a tiger from Burma, in which a third premolar is developed on one side. The specimen is interesting, because in the extinct feline genus *Pseudælurus* the third premolar is always present. *Pseudælurus* was founded on a Miocene fossil from Sansan, in France, and other species have been described from the Pliocene of Nebraska, and from the Sevaliks.

Entoniscus in France.—Among the parasitic crustaceans described by Dr. Fritz Müller perhaps none was more curious than that to which he gave the name of *Entoniscus*, a true isopod crustacean, the female of which, after a short free life, took up its abode in the abdomen of a crab, and became converted into a great sac branching about among the viscera of its host. Hitherto these parasites have been only known to occur on the Brazilian coast, where they were studied by the distinguished naturalist above-mentioned; but M. Giard has now discovered two species on the coast of France, one of which, however, he believes to have been seen long since by Cavolini. The commonest of the two species, which M. Giard names *Entoniscus Cavolinii*, is found under the carapace of *Grapsus marmoratus*, Fab., an abundant species on the rocks at Pouliguen, Loire-Inférieure; and the parasite is so numerous that out of thirty crabs one will usually be found to bear it. The second species is much less common, occurring only in about 1 per cent. of the crabs on which it is parasitic, the Velvet Crab (*Portunus puber*), a British species. To this M. Giard gives the name of *Entoniscus Moniezii*. It is unnecessary here to indicate the characters of the species, but some remarks of M. Giard's upon the active embryo of *Entoniscus Cavolinii* are of considerable interest. He finds that, besides the lateral eyes, which are double and correspond to the eyes of the normal isopods, the embryo possesses a median eye, composed of two contiguous crystallines, with pigment and optic nerves. This he regards as the Nauplian eye, which has persisted, retaining a structure such as is met with in many copepods, and which afterwards disappears with the secondary eyes during the retrograde metamorphosis of the female *Entoniscus*. This fact is of special importance, if it is a real trace of the occurrence of a Nauplius stage in the development of this curious isopod. (*Comptes rendus*, September 2, 1878.)

Circulation in Insects.—Mr. S. H. Scudder has read before the Boston Society of Natural History (*Proc.* vol. xix. part 1), some remarks upon the circulation of insects, a subject upon which, as he justly says, many contradictory views have been held. He says the juices of the digested food appear to pass directly through the thin walls of the alimentary canal into the general cavity of the body; from this they are pumped into the hinder extremity of the pulsatory dorsal vessel, by its alternate contractions and dilatations, while in many cases portions also appear to enter the sides of the vessel just in advance of the valves which aid the pulsating action by allowing a free passage to the fluid only in a forward direction. In the larval state the walls of the pseudocardium are often so slight as to be scarcely perceptible; but they are distinct in the imago, and as the vessel contracts

towards the head of the larva its nature becomes more apparent. More than a century ago Lyonnet showed that the dorsal vessel of the goat-moth-caterpillar has only a single outlet for the passage of the fluids, namely, where it terminates with a flaring opening at the extreme front of the head, just above the base of the œsophagus, into a cavity closed by membrane. The direct passage of the fluids thence has never been observed, but they must in some way at once enter the passages surrounding the tracheæ, since they are next found circulating in these all over the body. Other writers have described the anterior extremity as branching, but in like manner have not traced the passage of the fluids beyond the main trunk.

Mr. Scudder remarks that the only large tracheal vessel connecting the two sides of the body lies in the first segment behind the head; and that according to the little-known investigations of Barthélemy,* this transverse tracheal conduit appears at the earliest formation of the system in the embryo, before any regular distribution of fluids over the body can be observed; from the middle line of this transverse trachea half a dozen or more prominent branches pass directly forward, and some, at least, of their branches penetrate the cavity into which the dorsal vessel empties its contents. It is, therefore, highly probable that through them the fluids enter the peri-tracheal system, for by this channel the fluids would pass in the easiest possible manner to every part of the body from the moment that the pulsations of the dorsal vessel commence in the embryo. This, therefore, is the principal point towards which it is desirable that future investigations should be directed; and especially the structure of the tracheal threads which enter this cavity should be minutely studied.

The tracheæ, as shown by several anatomists, consist of two entirely distinct parts, and although authors do not wholly agree in their explanation of the structure of the tracheæ, there appears to be little doubt that it is substantially as follows:—First, a main stem and its branches, in which, between investing tissues, lies a closely-coiled spiral thread; and outside of and enveloping which is the peri-tracheal vessel, whose outer walls are not limited by the extent of the tracheæ proper, but extend beyond the spiral coil to form the second and distinct part of the system, namely, capillary tubes, penetrating every portion and organ of the body, and terminating in a meshwork of interlacing branches. In other words, this portion of the circulatory system consists of branching tubes, which enclose within all but their ultimate ramifications the similarly branching tubes of the respiratory system. The fluids, therefore, forced by the dorsal vessel into the peri-tracheal cavities, become thoroughly aerated before passing into the tissues of the body to perform their functions; when they have done their work, they empty themselves into the general cavity of the body, and mingling with the fluids newly expressed from the alimentary canal, join the general currents, which, as first shown by Carus, appear to set in regular channels at the sides and floor of the body, often, however, with no vascular boundaries, towards the hinder extremity of the body, or towards the sides of the dorsal vessel, to enter again the initial point of the circulation.

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* "Recherches d'Anatomie et de Physiologie Générales sur la classe des Lépidoptères." Toulouse, 1864.

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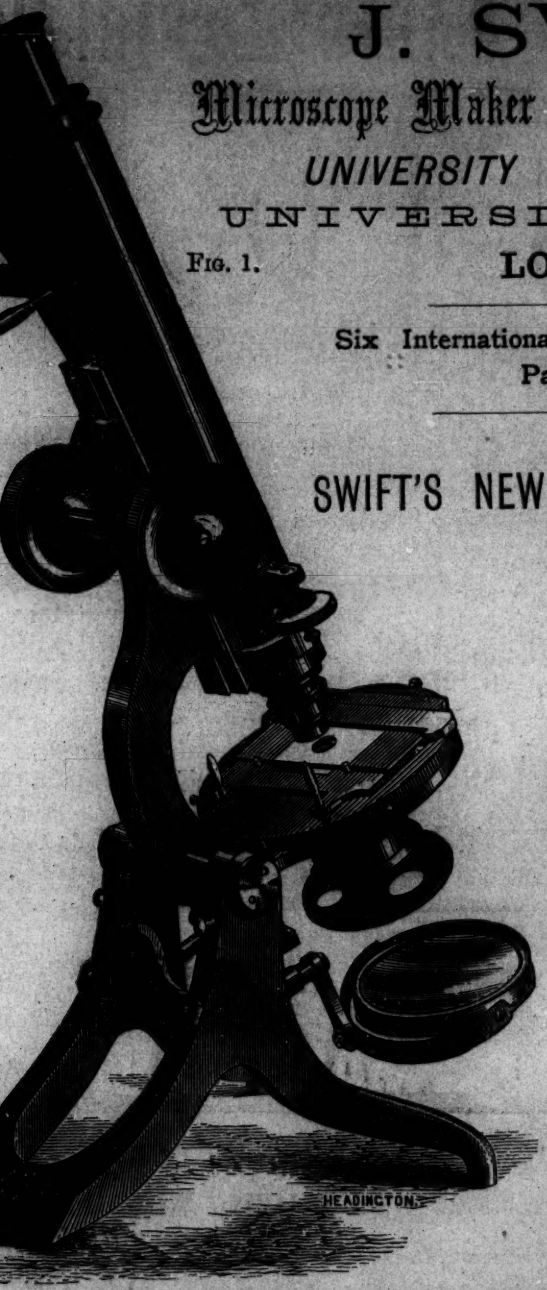
UNIVERSITY STREET,

LONDON, W.C.

Fig. 1.



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(Fig. 1.)

SWIFT'S NEW CHALLENGE BINOCULAR CONCENTRIC STAGE MICROSCOPE.

The Microscope, with best 1-in. and 90° $\frac{1}{4}$-in. Objectives, large Condensing Lens on Stand, packed in mahogany cabinet, price **£14**

This Microscope has received the honoured distinction of the Gold Medal at the late Exhibition, Paris, 1875; and also the same honour was conferred upon it at the Brussels Exhibition, 1876, for its superior construction, workmanship, and optical performance over all competitors. The above stands without a rival.

(Fig. 2.)

SWIFT'S NEW COLLEGE MICROSCOPE,

With Eye-Piece, 1-in. and $\frac{1}{4}$-in. Objectives, in mahogany cabinet **£5 5**

Or with $\frac{1}{8}$-in. instead of $\frac{1}{4}$-in. Objectives, Condenser on Stand, extra high power Eye-Piece **6 12**

ILLUSTRATED CATALOGUE FOR STAMP.

Fig. 3.

Fig. 4.

SWIFT'S NEW NOSE-PIECE TO MICROSCOPE,

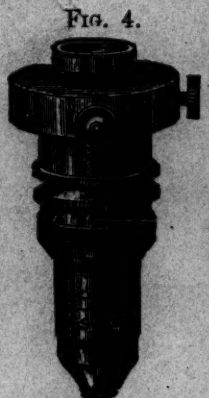
By which means an Objective can be readily centred to the stage of Microscope.

ACHROMATIC CONDENSER &c.

Fig. 3.

Swift's Nose-Piece for Two Objectives,

Fig. 4.



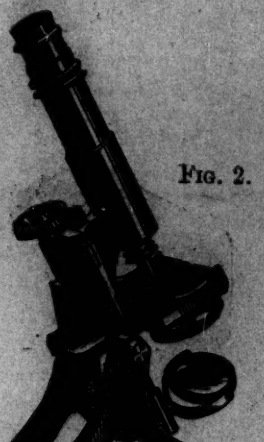


Fig. 2.

GOLD MEDAL, PARIS EXHIBITION.

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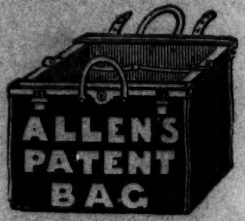

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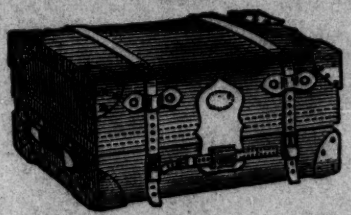

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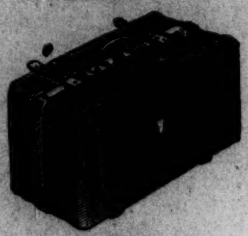

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